Exploitation Assessment of Five Southeastern Ontario Lake Trout Fisheries Supplemented by Stocking.

Rideau Lakes
Fisheries Assessment Unit
Report No.17

J.A. Hoyle
N.G. MacLean

Rideau Lakes
Fisheries Assessment Unit
R.R. 2 Sharbot Lake
Ontario, KOH 2PO
(613) 335-2130

Printed in Ontario, Canada
©Government of Ontario, 1988.

Ontario
Ministry of Natural Resources
Hon. Vincent G. Kerrio
Minister
George Tough
Deputy Minister

ABSTRACT

The Rideau Lakes Fisheries Assessment Unit has collected trend-through-time data since 1981 for five lakes supporting lake trout populations. Though natural reproduction in these lakes remains significant, native lake trout populations are supplemented annually by stocking yearling lake trout. In this report, we focus on data (angling effort and lake trout yield, abundance, mean age in the anglers harvest, mortality, and growth) collected during creel surveys conducted annually and biennially for winter and summer lake trout seasons respectively from 1981 to 1986. We compare winter and summer lake trout fisheries, contrast the performance of native and stocked lake trout, and assess the level of exploitation on these lake trout populations.

TABLE OF CONTENTS

	Page
TITLE PAGE	1
ABSTRACT	ii
TABLE OF CONTENTS	iii
LIST OF FIGURES	v
LIST OF TABLES	vii
1. INTRODUCTION	1
2. THE STUDY LAKES	2
2.1. STOCKING HISTORY	2
2.2. OPEN SEASONS FOR LAKE TROUT ANGLING	2
3. METHODS	6
3.1. CREEL SURVEY DESIGN AND ANALYSIS	6
3.2. INDICES OF EXPLOITATION	6
3.2.1. Angling Effort	6
3.2.2. Yield	6
3.2.3. Relative Abundance	7
3.2.4. Mean Fork Length of the Harvest	7
3.2.5. Mortality	7
3.2.6. Growth	8
4. RESULTS AND DISCUSSION	9
4.1. BIG CLEAR LAKE	9
4.1.1. Angling Effort	9
4.1.2. Yield	9
4.1.3. Relative Abundance	9
4.1.4. Mean Fork Length of the Harvest	18
4.1.5. Mortality	18
4.1.6. Growth	18
4.2. BIG RIDEAU LAKE	18
4.2.1. Angling Effort	18
4.2.2. Yield	24
4.2.3. Relative Abundance	24
4.3.4. Mean Fork Length of the Harvest	24
4.3.5. Mortality	24
4.3.6. Growth	25
4.3. BIG SALMON LAKE	25
4.3.1. Angling Effort	25
4.3.2. Yield	25
4.3.3. Relative Abundance	27
4.3.4. Mean Fork Length of the Harvest	27
4.3.5. Mortality	27
4.3.6. Growth	27
4.4. CHARLESTON LAKE	28
4.4.1. Angling Effort	28
4.4.2. Yield	28
4.4.3. Relative Abundance	28
4.4.4. Mean Fork Length of the Harvest	28
4.4.5. Mortality	30
4.4.6. Growth	30
4.5. DEVIL LAKE	30

4.5.1. Angling Effort 30
4.5.2. Yield 30
4.5.3. Relative Abundance 32
4.5.4. Mean Fork Length of the Harvest 32
4.5.5. Mortality 32
4.5.6. Growth 32
5. STATUS OF THE LAKE TROUT FISHERIES 34
5.1. NATIVE LAKE TROUT POPULATIONS 35
5.1.1. Big Clear Lake 35
5.1.2. Big Rideau Lake 35
5.1.3. Big Salmon 35
5.1.4. Charleston 37
5.1.5. Devil 37
5.2. STOCKED LAKE TROUT POPULATIONS 37
6. SUMMARY 40
7. ACKNOWLEDGEMENTS 42
8. REFERENCES 43
9. APPENDIX 1 46

LIST OF FIGURES

Page

Figure 1. The Rideau Corridor and the five RLFAU lake trout community type study lakes. 3

Figure 2a-e. Winter, summer, and annual species specific (lake trout) angling effort (angler hours/ha) on five lakes over the study period (1981 to 1986). 10

Figure 3a-e. Winter, summer, annual, and recommended annual (see text for explanation) yield (kg/ha) of native lake trout from five lakes over the study period (1981 to 1986). 12

Figure 4a-e. Winter, summer, annual, and recommended (see text for explanation) annual yield (kg/ha) of stocked lake trout from five lakes over the study period (1981 to 1986). 13

Figure 5a-e. Winter, summer, annual, and recommended (see text for explanation) annual yield (kg/ha) of all (native and stocked) lake trout from five lakes over the study period (1981 to 1986). 14

Figure 6a-e. Winter and summer estimated species specific CUE for all lake trout on five lakes over the study period (1981 to 1986). 15

Figure 7a-e. Winter and summer estimated species specific HUE for native lake trout on five lakes over the study period (1981 to 1986). 16

Figure 8a-e. Winter and summer estimated species specific HUE for stocked lake trout on five lakes over the study period (1981 to 1986). 17

Figure 9a-e. Winter and summer mean fork length (mm) of native lake trout in the anglers harvest on five lakes over the study period (1981 to 1986). 19

Figure 10a-e. Winter and summer mean fork length (mm) of stocked lake trout in the anglers harvest on five lakes over the study period (1981 to 1986). 20

Figure 11a-e. Average annual age specific HUE's (log scale) for native and stocked lake trout harvested during winter and summer seasons. These 'catch curves' were used to calculate total annual mortality (see text for explanation). 21

Figure 12a-e. Mean fork length-at-age for native and stocked lake trout sampled during the six winter creel surveys on five study lakes over the study period (1981 to 1986). 22

LIST OF TABLES

Page

Table 1. Characteristics of the five study lakes. 4

Table 2. Lake trout stocking history for the five study lakes. 5

Table 3. Data summary for Big Clear Lake. Results are based on data collected from six winter and three summer creel surveys (summer yield, HUE, mean fork length of the harvest, and mortality estimates are based on two summer creels only, since too few lake trout were sampled during the 1985 summer creel survey). See text for explanation of calculations. 11

Table 4. Data summary for Big Rideau Lake. Results are based on data collected from six winter and three summer creel surveys. See text for explanation of calculations. 23

Table 5. Data summary for Big Salmon Lake. Results are based on data collected from six winter and two summer (summer 1985 volunteer data thrown out) creel surveys. See text for explanation of calculations. 26

Table 6. Data summary for Charleston Lake. Results are based on data collected from six winter and three summer creel surveys. See text for explanation of calculations. 29

Table 7. Data summary for Devil Lake. Results are based on data collected from six winter and three summer creel surveys. See text for explanation of calculations. 31

Table 8. Percentage of annual effort and yield and the yield per unit effort (kg/ha) of all lake trout which occurred during the winter and summer seasons (1981 to 1986) on the five study lakes. 34

Table 9. Summary table listing the indices of exploitation for the native lake trout populations only in the five study lakes. 36

1. INTRODUCTION

The Rideau Lakes Fisheries Assessment Unit (RLFAU) initiated a long term creel survey program on five lake trout community 'type' (MNR 1978) lakes (Big Clear, Big Rideau, Big Salmon, Charleston, and Devil Lakes) beginning in 1981. The program was designed to provide trend-through-time information on these lakes' sport fisheries, i.e. estimates of angler effort and success, catch, and harvest; length, weight, nd age structures of the harvest; fishing methods; and user group characteristics. Results of annual winter surveys and biennial summer surveys have previously been reported as RLFAU reports (MacLean and Schlesinger 1982, Schlesinger and MacLean 1983, Barnes et al. 1984, Claytor et al. 1985, Paleczny 1987).

This report focuses on the lake trout fisheries in these lakes from 1981 to 1986, a 6-year time period falling between major sport fishing regulation changes in 1980 and 1987; changes aimed at reducing lake trout harvest levels. We follow the approach of SPOF Working Group No. 15 (MNR 1983), and examine various indices of overexploitation: angling effort, yield, relative abundance (catch per unit effort), mean fork length of the harvest, total annual mortality, and growth.

Specifically, the objectives of this report are:
1) to characterize these 'split season' (winter and summer) lake trout sport fisheries, by documenting year-to-year variation in angler effort, and lake trout yield;
2) to assess the current (1981 to 1986) level of angler exploitation and the impact of past exploitation on the lake trout populations by examining indicators of overexploitation;
3) to compare and contrast native and stocked lake trout populations in terms of their contributions to the sport fishery, growth, and survival; and
4) to provide solid background data for future assessment of these lake trout stocks following lake trout sport fishing regulation changes (eg. 1987).

Studies of this nature are essential for comparisons across lake trout community types throughout Ontario. Our findings have immediate relevance to local fisheries managers.

2. THE STUDY LAKES

Big Clear, Big Rideau, Big Salmon, and Devil Lakes are located along the Rideau Corridor (Fig. 1) in the 'Rideau Lakes' watershed; Charleston Lake is in a separate watershed that flows into the Gananoque River system via Wiltse Creek. Selected physical, chemical, and biological characteristics of the five study lakes appear in Table 1. Further information pertaining to physical parameters, shoreline development, water quality, and the historical sequence of stresses on the lakes' fisheries can be found in MacLean and Hooper (1981) (see also update in Claytor et al. (1985)).

The three largest lakes, Big Rideau, Charleston, and Devil, are readily accessible to anglers year-round. Big Clear Lake is accessible by snowmobile during the winter, but the lack of a developed public access places some limitations on angling effort during the summer season. Big Salmon Lake, located in Frontenac Provincial Park, has certain travel restrictions. The single road access is closed to traffic from November to April of each year. No snowmobiles have been allowed to travel in the park since the mid-1970's and outboard motors were banned beginning in 1984. Although Frontenac Provincial Park was largely undeveloped and used primarily by a few well-motivated anglers in 1981, it was developed for multi-user use during the course of the study period.

The lake trout populations of the study lakes are predominantly piscivorous as evidenced by stomach content analysis of angled fish (February 1984, RLFAU data files). Alewife, present in Big Rideau and Charleston Lakes only, formed the bulk of the lake trout diet in these two lakes. Fish species present in lake trout stomachs from Big Clear, Big Salmon, and Devil included herring, sculpin, and minnows (mostly anglers' baitfish). Opossum shrimp (Mysis relicta) also formed a numerically significant part of the diet in Big Clear, Big Salmon, and Devil Lakes.

2.1 STOCKING HISTORY

Lake trout are native to all five lakes. However, for many years managers have attempted to supplement native populations by stocking yearling lake trout (Table 2) (see MacLean and Hooper 1981 for a complete stocking history up to 1981).

2.2 OPEN SEASONS FOR LAKE TROUT ANGLING

During the study period, two open angling seasons ('split season') occurred annually on each lake. The first season covered a 15-day period in February (first Saturday to the third Sunday); the second extended from the first Saturday in June to 8

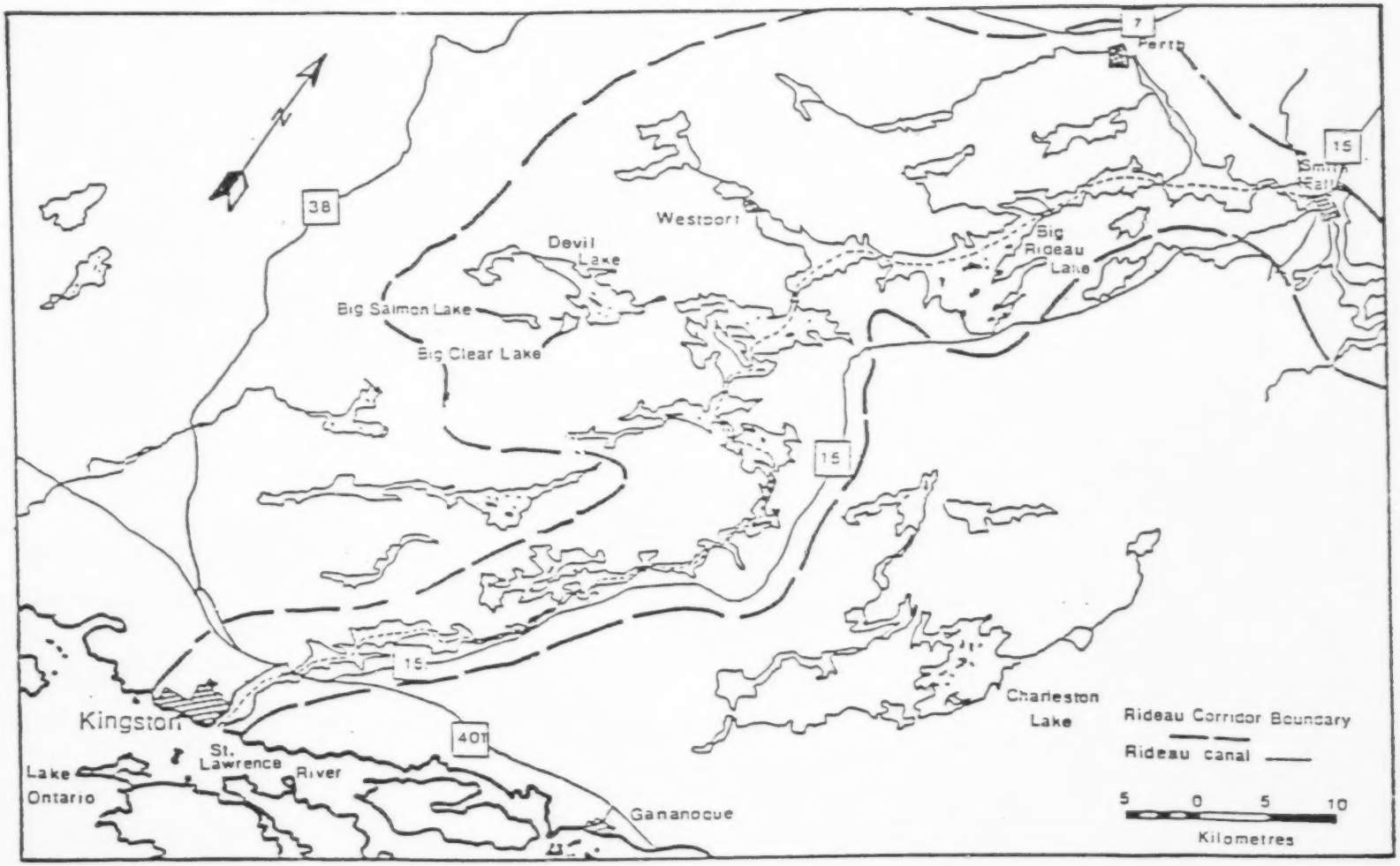

Figure 1. The Rideau Corridor and the five RLFAU lake trout community type study lakes.

Table 1. Characteristics of the five study lakes.

Lake	Lat., Long.	Area (ha)	Mean Depth (m)	MEI	Potential Fish Production (kg/ha/yr)	Recommended Lake Trout Yield (kg/ha/yr)	Community Type
Big Clear	4433N,7628W	187.4	20.1	2.5	2.11	0.53	18
Big Rideau	4445N,7613W	5761.0	13.3	10.4	4.02	1.01	31
Big Salmon	4432N,7630W	148.1	13.2	4.5	2.75	0.69	18
Charleston	4432N,7600W	2517.2	17.4	7.9	3.55	0.89	30
Devil	4435N,7627W	1061.5	14.4	7.6	3.48	0.87	22

MEI = Morphoedaphic Index (Ryder 1965)
Potential Fish Production = $1.4(MEI)^{0.45}$ (Ryder 1965)
Recommended Lake Trout Yield = Potential Fish Production x 25% (MNR 1982)
Community Type: 18 = lake trout, smallmouth bass; 22 = lake trout, smallmouth bass, northern pike; 30 = lake trout, smallmouth bass, northern pike, lake whitefish; 31 = lake trout, smallmouth bass, northern pike, lake whitefish, walleye (MNR 1978). Largemouth bass are also present in all five study lakes.

September.

Table 2. Lake trout stocking history for the five study lakes.

Lake	Initial Year of Stocking	Yearling Lake Trout Stocking Rate 1971-1980	
		Mean #/yr (# yrs)	#/ha/yr
Big Clear	1934 (fingerlings)	1838 (8)	9.8
Big Rideau	1890 (fry)	16707 (10)	2.9
Big Salmon	1952 (yearlings)	1185 (8)	8.0
Charleston	1888 (fry)	17620 (10)	7.0
Devil	1924 (fry)	6053 (9)	5.7

3. METHODS

3.1. CREEL SURVEY DESIGN AND ANALYSIS

Winter creel surveys were carried out annually (1981 to 1986) and summer creels biennially (1981, 1983, 1985) on each lake. All surveys followed a roving stratified design, with one exception. In view of low angling effort during the summer open season on Big Salmon Lake, we ran a volunteer creel census. Details of creel survey field methods can be found in MacLean and Smith (1985a, 1985b). Each survey was stratified by area, season, day-type, and time-period. Overall, 40% of available week days and 50% of available weekend days were sampled on each lake during winter; 22% and 45% of week days and weekend days respectively were sampled during the summer season.

From 1981 to 1983 (winter), computer programs developed by the Lake Erie Fisheries Assessment Unit (Petzold 1980) were used to calculate estimates of catch, harvest and effort. From 1983 (summer) to 1986, various versions of CREESYS were used for analysis (Lester and Trippel 1985). Test runs using the two analysis packages have produced the same results. Volunteer creel data for the summer fishery on Big Salmon Lake was expanded using boat trailer counts made by park staff, and mean party size reported by anglers.

Biological attributes from a random sample of harvested lake trout were recorded each sample day. (Appendix 1 shows the total numbers of lake trout sampled). Each lake trout sampled was checked for the presence of clipped fins (in order to separate native from stocked fish), and measured for fork length (to the nearest 1 mm) and weight (to nearest 25 gm). Scales were collected for ageing purposes.

3.2. INDICES OF EXPLOITATION

Indices of exploitation were calculated for each fishery following SPOF 15 (MNR 1983). The indices are described below.

3.2.1. Angling Effort

Species specific (lake trout) angling effort (angler hours/ha) was determined for winter and summer lake trout seasons. Because anglers were allowed two lines for winter fishing, the mean number of rods per angler was also determined. Following Hoyle and Stewart (1987), we classified angler effort less than 5 hours/ha/yr as light pressure; 5 to 10 hours/ha/yr moderate; and greater than 10 hours/ha as heavy fishing pressure.

3.2.2. Yield

Lake trout yield (kg/ha) was calculated by multiplying the estimated number of lake trout harvested (by all anglers) and the

mean weight of sampled lake trout. Yield is reported separately for winter and summer seasons and for native and stocked fish. The ratio of observed to recommended annual lake trout yield (RORY) (MNR 1982, Schlesinger and MacLean 1983) was calculated for native lake trout only and used to measure the degree of angling exploitation on the native lake trout population over the study period.

Recommended yields range from about 0.5 to 1.0 kg/ha/yr on our study lakes (Table 1). Healey (1978) however, suggested that lake trout populations were unlikely to withstand annual yields in excess of 0.5 kg/ha.

3.2.3. Relative Abundance

Estimated species specific catch per unit effort (CUE) data were considered as an index of total lake trout abundance and used primarily to contrast winter and summer angling success and to make inter-lake comparisons. Estimated species specific harvest per unit effort (HUE) data were used to index the relative abundance of native and stocked fish. Variation in abundance was described by the coefficient of variation (C.V.) in mean annual winter and summer CUE's and HUE's. A coefficient of variation greater than 0.35 was considered indicative of a stressed population (MNR 1983).

3.2.4. Mean fork length of the harvest

Declining mean age of the harvest is often associated with overexploitation (MNR 1983). However, we examined mean lengths rather than age to avoid problems associated with inaccurate age assessment (i.e. for lake trout not included in the VI to IX age group as described above). An increase in growth rate (due to reduced intraspecific competition for food) is the usual response to heavy exploitation (MNR 1983). However, we suspect that there is no further room for this sort of growth compensation because these lake trout fisheries have been heavily exploited for many years. Hence, we interpret a change in mean fork length as reflecting a change in the age structure of the lake trout population.

Mean fork lengths of angler harvested native and stocked lake trout sampled during creel surveys were calculated for each open season and compared using t-tests ($p=.05$).

3.2.5. Mortality

Total annual mortality was estimated by catch curve analysis using average annual age specific HUE's over the six year study period. Mortality was calculated separately by season for native and stocked lake trout. The first age class fully recruited to the sports fishery was considered to be the modal age class plus one. We had greatest confidence in our scale age assessment for lake trout aged VI to IX years (Hoyle and MacLean 1988). Therefore, we used that age range to calculate mortality when the modal age was V years (or less). In the few cases where the modal age was VI years, lake trout aged VII to IX years were

used. Harvest per unit effort values were 'smoothed' with a running average of three as suggested by Ricker (1975).

Total annual mortalities greater than 0.50 were considered to entail high risk of instability or collapse of the lake trout fishery (MNR 1983).

3.2.6. Growth

Mean fork length-at-age values were determined for native and stocked lake trout sampled during winter creel surveys. For age groups VI and VII, the mean fork lengths of native and stocked fish were compared using t-tests or Mann-Whitney U-tests ($p=.05$). Also for ages VI and VII, mean growth indices were calculated using the growth standards (mean fork length) for 'average' Ontario lake trout (MNR 1983).

4. RESULTS AND DISCUSSION

4.1. BIG CLEAR LAKE

4.1.1. Angling Effort

Angler effort during the two week winter season was very high on Big Clear Lake, ranging from about 15 to 25 hours/ha (Fig. 2a), with an annual mean of 17.9 hours/ha over the six years (Table 3). Most fishermen used two lines at this time (6-year mean number of rods/angler=1.9).

By contrast, total summer effort was consistently much lower, averaging 1.9 hours/ha. As described above, Big Clear Lake is relatively inaccessible during the summer with no developed public access.

Mean annual effort on Big Clear Lake was high, about 20 hours/ha. No obvious year-to-year trends in angler effort were detected.

4.1.2. Yield

Yield of native lake trout during the winter season generally greatly exceeded the recommended annual yield of 0.53 kg/ha, ranging from about 0.5 to 2 kg/ha (Fig. 3a) and with a 6-year mean of 1.24 kg/ha (Table 3). Yield of stocked lake trout hovered around 0.5 kg/ha, but strayed to 1.7 kg/ha in the winter of 1982 (Fig. 4a), resulting in a 6-year mean of 0.68 kg/ha.

Corresponding to low summer angling effort, yields of both native and stocked lake trout were low during the summer season at 0.16 and 0.09 kg/ha respectively (based on two years data only; only one fish was sampled in 1985). Thus, mean annual yield was about twice as great for native lake trout (1.40 kg/ha, RORY=2.64) compared to stocked lake trout (0.77 kg/ha). Total annual lake trout yield appears to have decreased slightly over the study period (Fig.5a).

4.1.3. Relative Abundance

No obvious year-to-year trends in lake trout angler CUE were apparent (Fig. 6a), but CUE's were generally greater in winter (6-year mean=0.199) than summer (3-year mean=0.131).

Harvest per unit effort was highly variable for native lake trout (Fig. 7a, C.V.=0.39 for both winter and summer HUE estimates). Mean winter and summer HUE's for native lake trout were 0.087 and 0.049 respectively (Table 3). The summer HUE values represent only two years data, since the proportions of native and stocked lake trout in the harvest could not be determined for the summer of 1985 (only one fish sampled).

Harvest per unit effort was more stable (winter C.V.=0.24) for stocked lake trout (Fig. 8a). Mean winter and summer HUE's for stocked lake trout were 0.49 and 0.24 respectively.

In summary, winter HUE's were about twice those of summer and native lake trout HUE's were about twice those of stocked lake trout in Big Clear Lake.

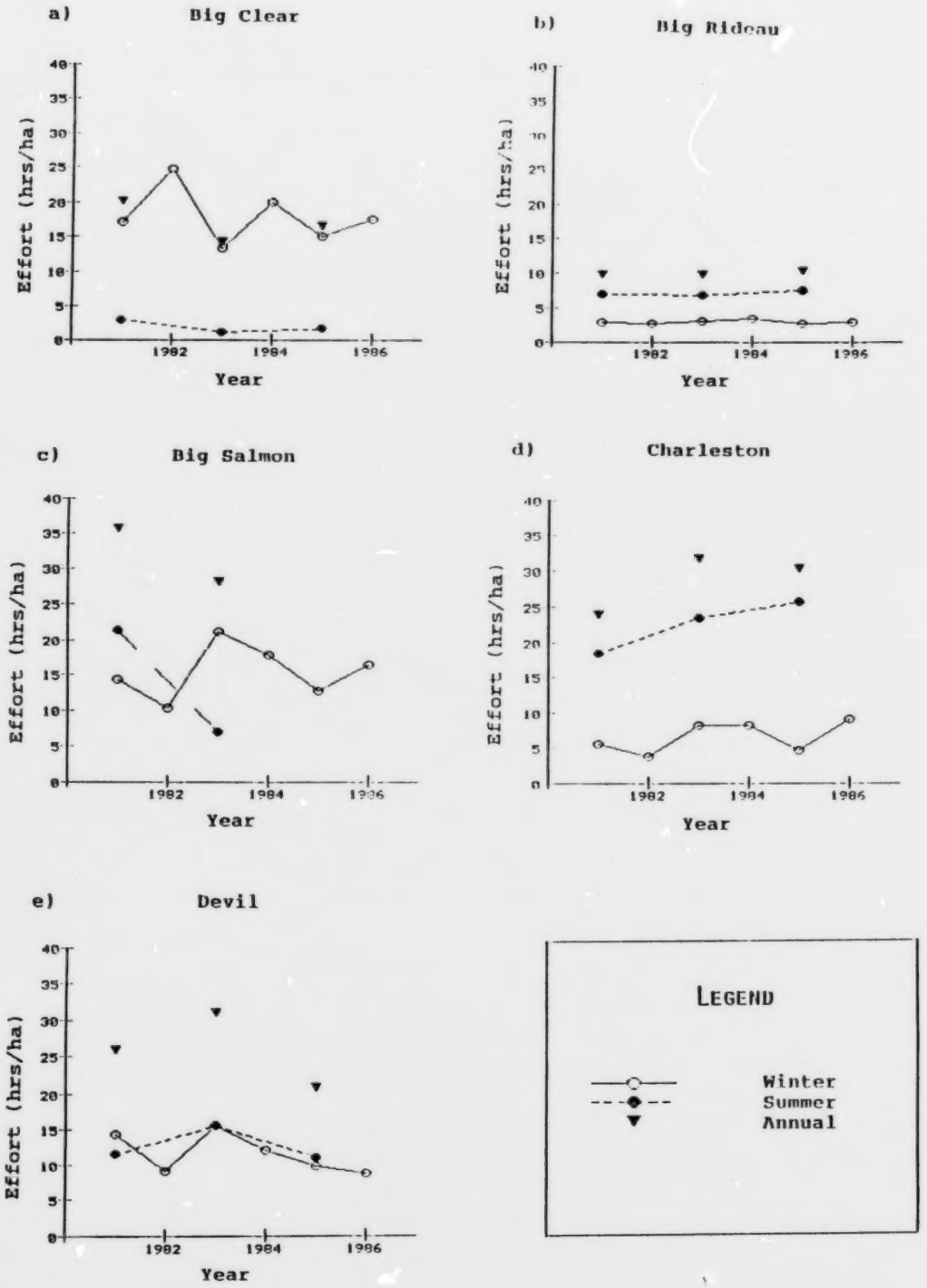

Figure 2a-e. Winter, summer, and annual species specific (lake trout) angling effort (angler hours/ha) on five lakes over the study period (1981 to 1986).

Table 3. Data summary for Big Clear Lake. Results are based on data collected from six winter and three summer creel surveys (summer yield, HUE, mean fork length of the harvest, and mortality estimates are based on two summer creels only since too few lake trout were sampled during the 1985 summer creel survey). See text for explanation of calculations.

		Effort (angler hours/ha)	Yield kg/ha	Yield RORY	Abundance CUE (C.V.)	Abundance HUE (C.V.)	Mean Fork Length (mm)	Total Annual Mortality (Ages VI to IX)	Mean Growth Index for Ages VI and VII
Winter									
	Native	-	1.24	2.34	-	.087 (.39)	378	.40	-
	Stocked	-	.68	-	-	.074 (.24)	333	.42	-
	Total	17.9 (1.9*)	1.92	-	.199 (.32)	.161	358	-	-
Summer									
	Native	-	.16	.30	-	.049 (.39)	470	.54	-
	Stocked	-	.09	-	-	.024 (1.38)	465	**	-
	Total	1.9	.25	-	.131 (.70)	.073	468	-	-
Annual									
	Native	-	1.40	2.64	-	-	-	-	94%
	Stocked	-	.77	-	-	-	-	-	91%
	Total	19.8	2.17	-	-	-	-	-	-

(* = # rods/angler; ** = insufficient data; blank = not applicable)

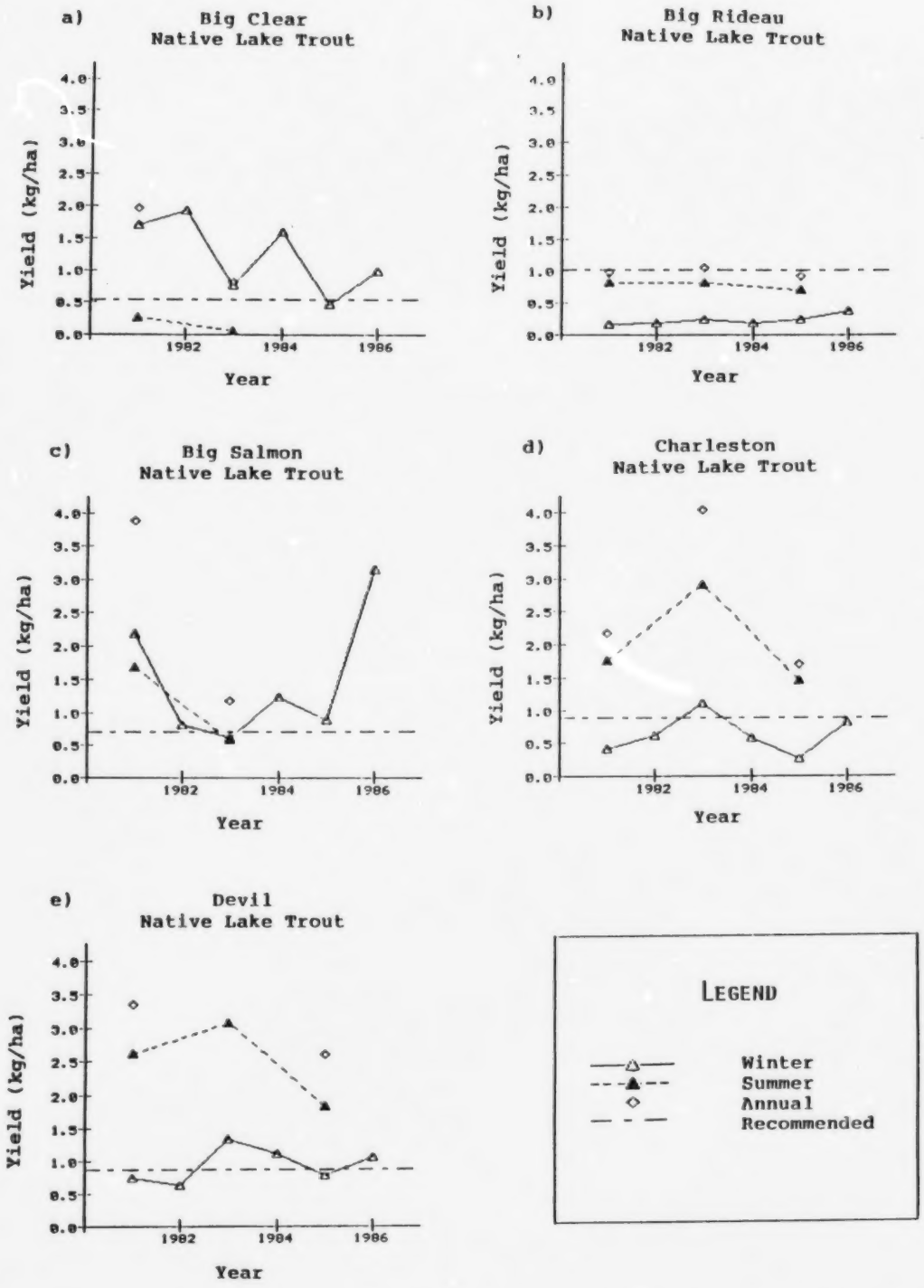

Figure 3a-e. Winter, summer, annual, and recommended annual (see text for explanation) yield (kg/ha) of native lake trout from five lakes over the study period (1981-1986).

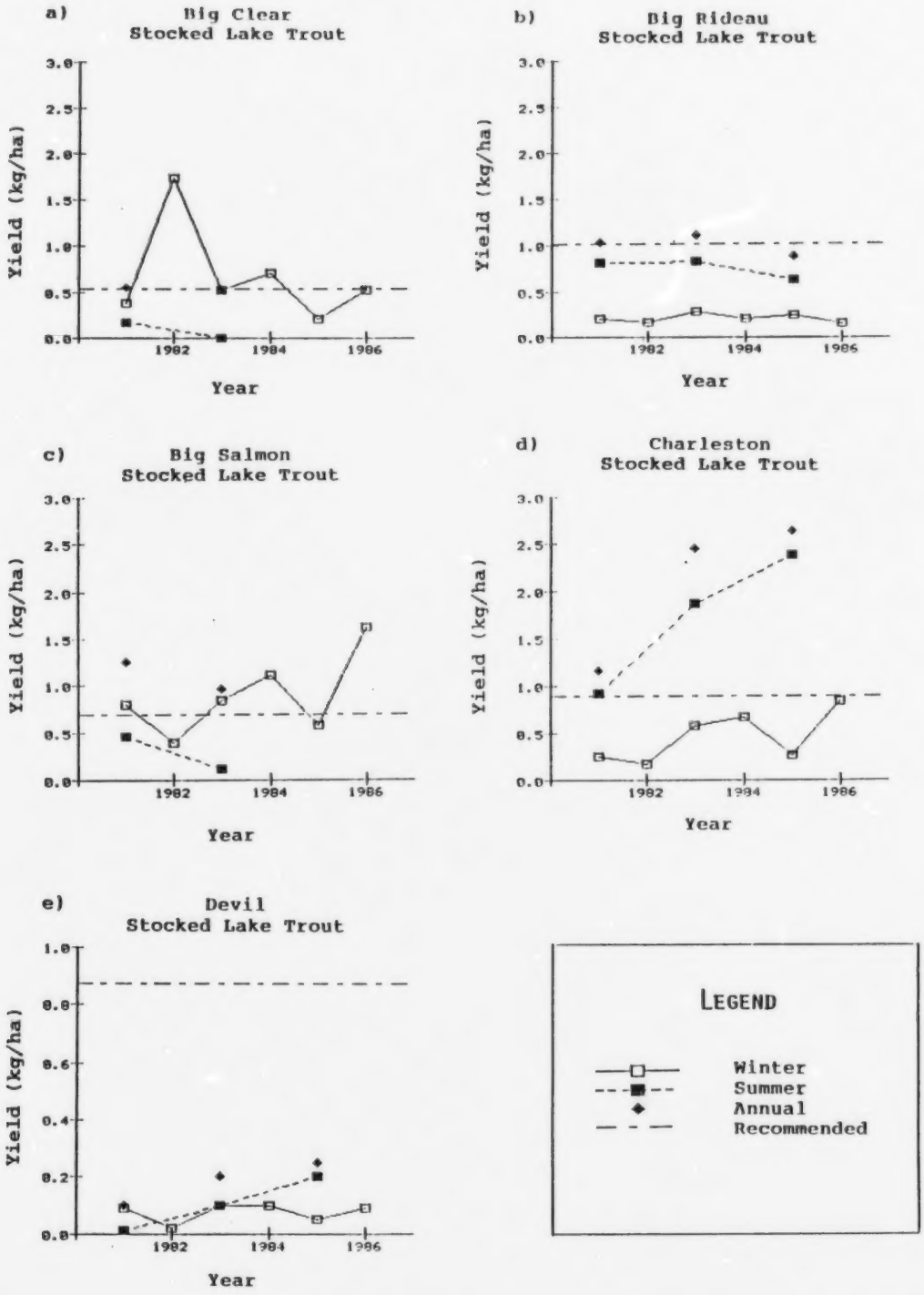

Figure 4a-e. Winter, summer, annual, and recommended (see text for explanation) annual yield (kg/ha) of **stocked** lake trout from five lakes over the study period (1981-86).

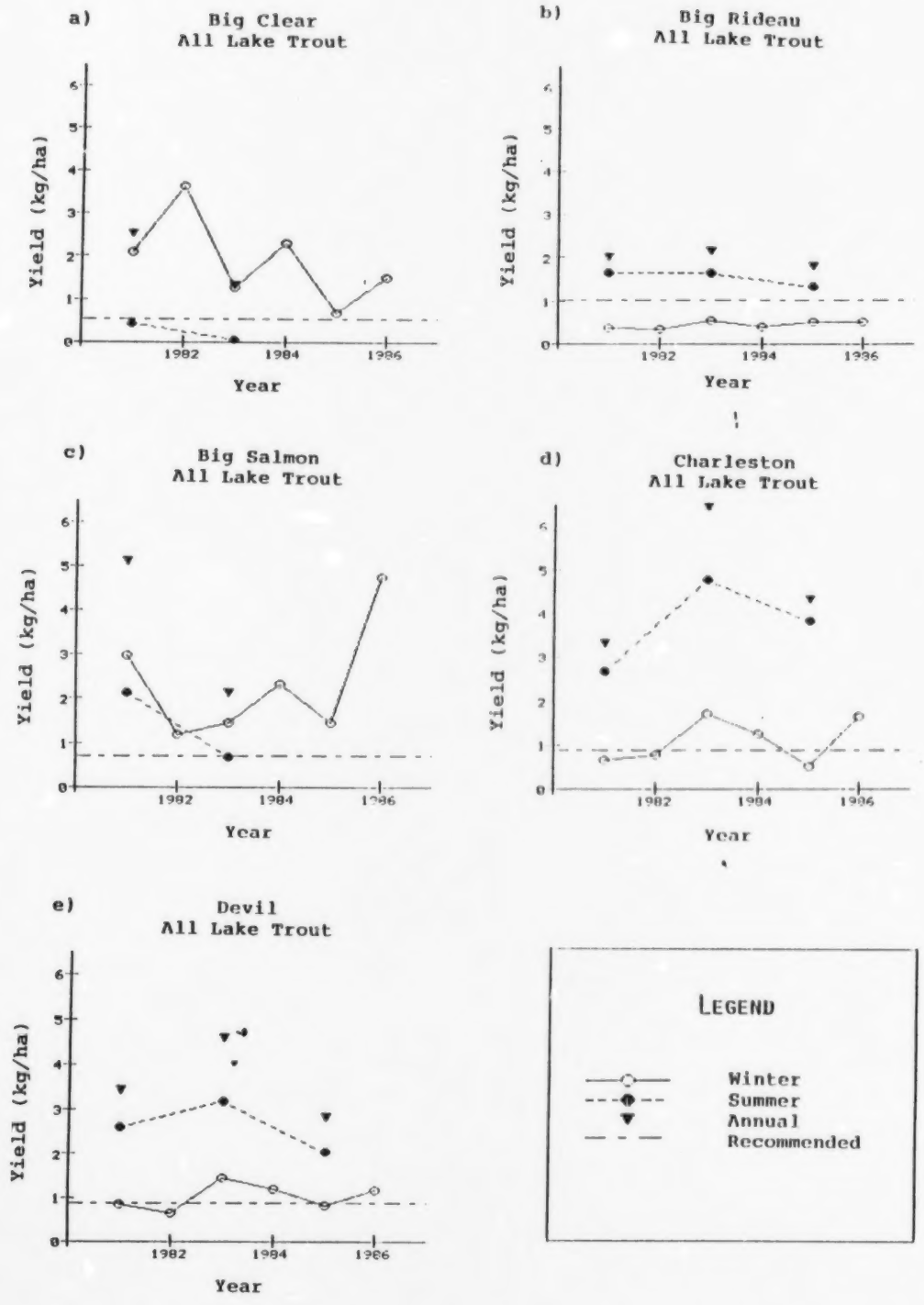

Figure 5a-e. Winter, summer, annual, and recommended (see text for explanation) annual yield (kg/ha) of **all** (**native** and **stocked**) lake trout from five lakes over the study period (1981 to 1986).

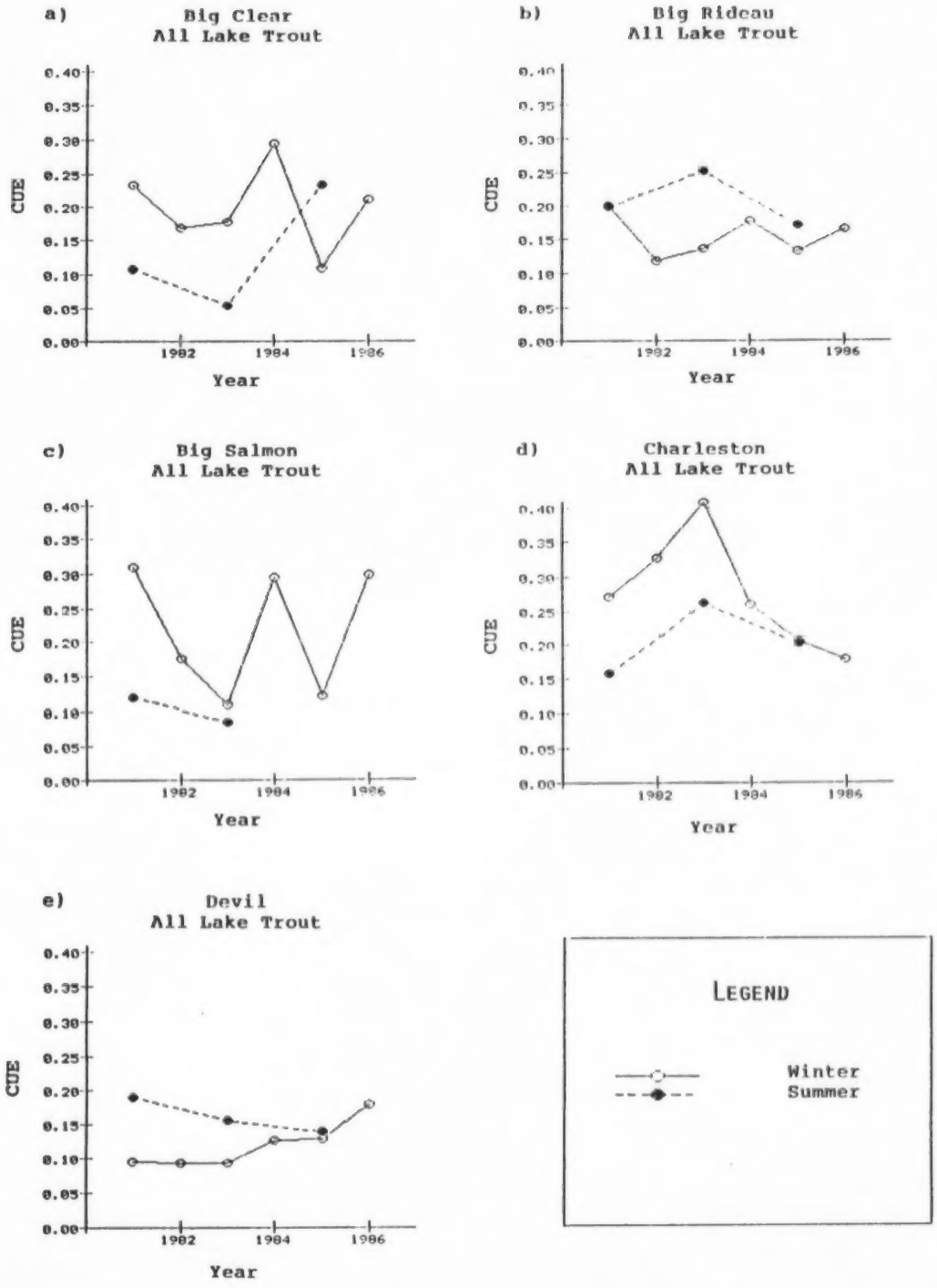

Figure 6a-e. Winter and summer estimated species specific CUE for **all** lake trout on five lakes over the study period (1981-1986).

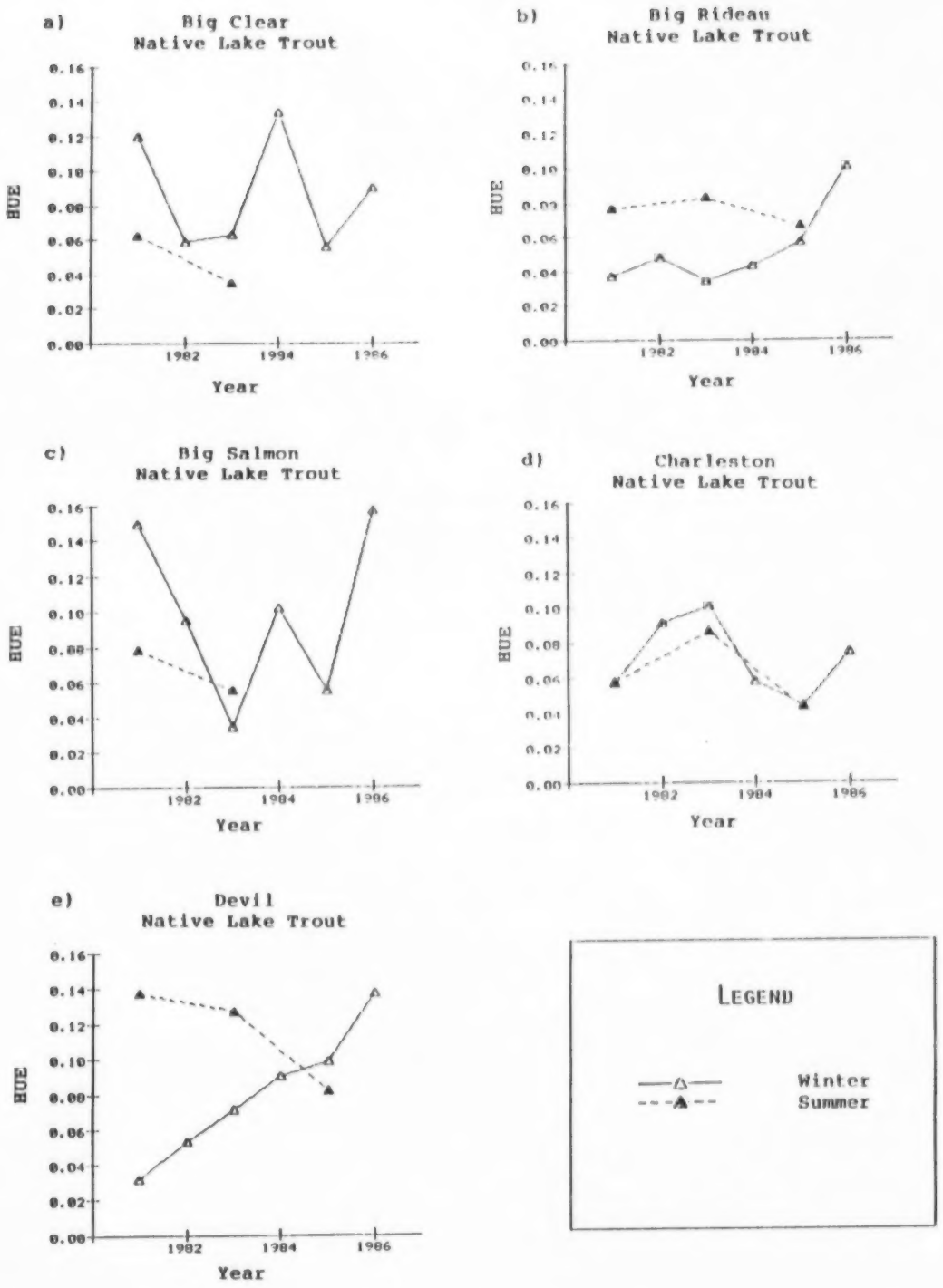

Figure 7a-e. Winter and summer estimated species specific HUE for native lake trout on five lakes over the study period (1981-86).

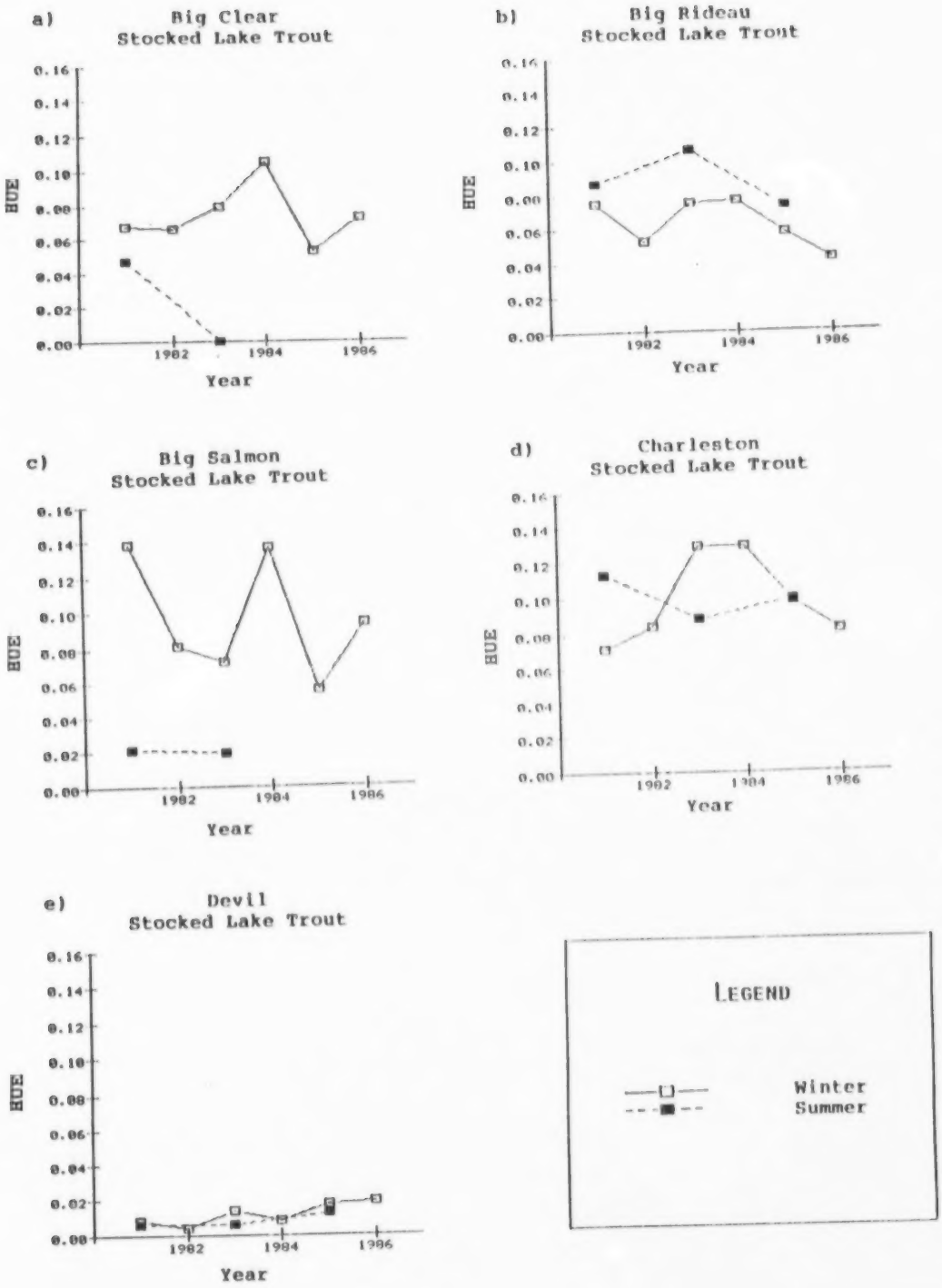

Figure 8a-e. Winter and summer estimated species specific HUE for **stocked** lake trout on five lakes over the study period (1981 to 1986).

4.1.4. Mean Fork Length of the Harvest

Mean fork length of the harvest (for native and stocked lake trout) appears to have declined somewhat over the study period (Figs. 9a, 10a). The mean fork length of native lake trout was larger (6-year mean=378 mm) than that of stocked fish (6-year mean=333 mm) during the winter season ($p<.05$). Native lake trout were of greater mean fork length in summer (2-year mean=470 mm) than winter ($p<.05$) (Table 3). Too few stocked lake trout were sampled during the summer to allow statistical comparisons.

4.1.5. Mortality

Catch curves (lake trout age class vs. HUE on log scale) are shown in Fig. 11a by season for native and stocked fish. Native lake trout fully recruited to the winter fishery at an earlier age (VI), than to the summer fishery (age VII). Catch curves for native and planted fish are similar over the VI to IX age group, but few stocked fish over age X are harvested from Big Clear Lake.

Our estimate of total annual mortality for native lake trout in Big Clear Lake was 0.40 for winter data and 0.54 for summer data (Table 3). The winter mortality estimate for stocked lake trout was 0.42. Too few stocked fish were sampled during summer seasons to estimate mortality.

4.1.6. Growth

Mean fork lengths-at-age for native and stocked lake trout are shown in Fig. 12a. Fork lengths-at-age were generally greater for native lake trout but not significantly so at ages VI and VII (Mann-Whitney U-test, $p>.05$) (native: mean=367 mm, n=37 at age VI and mean=436 mm, n=26 at age VII; stocked: mean=356 mm, n=29 at age VI and mean=415 mm, n=14 at age VII).

Mean growth indices for ages VI and VII were less for both native and stocked lake trout than the Ontario 'average' (94 and 91% respectively) (Table 3).

4.2. BIG RIDEAU LAKE

4.2.1. Angling Effort

Angling effort was remarkably consistent from year-to-year on Big Rideau Lake for both winter and summer lake trout fisheries (Fig. 2b). Mean angling effort during the winter season was low (6-year mean=3.0 hours/ha) compared with the other lakes. Many fishermen elected to use only one line (mean number of rods/angler=1.3) (Table 4).

Mean angling effort during the summer was more than twice that of winter (3-year summer mean = 7.1 hours/ha) for a mean annual angling effort of 10.1 hours/ha. We consider this moderate fishing pressure.

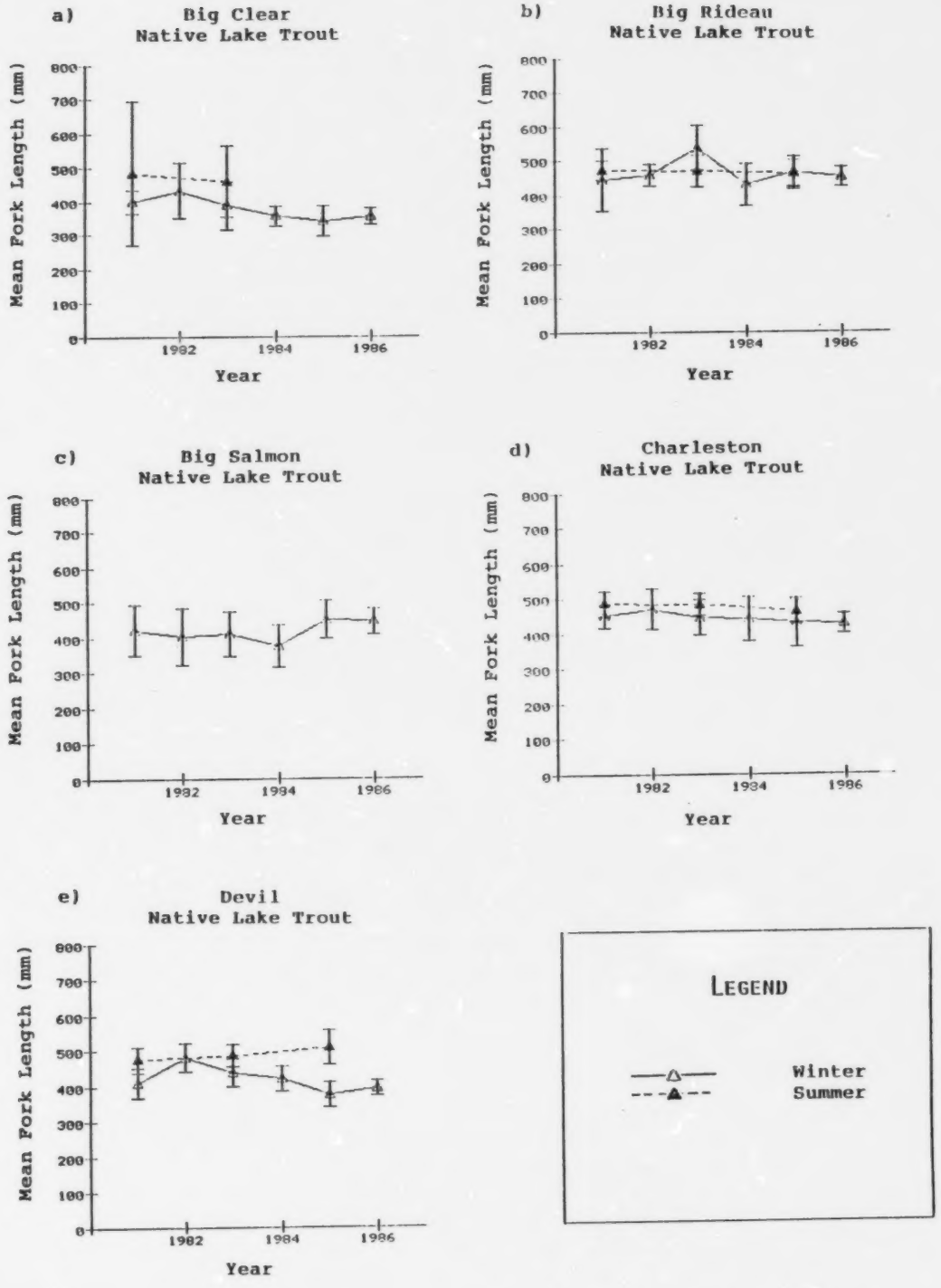

Figure 9a-e. Winter and summer mean fork length (mm) of native lake trout in the anglers harvest on five lakes over the study period (1981 to 1986).

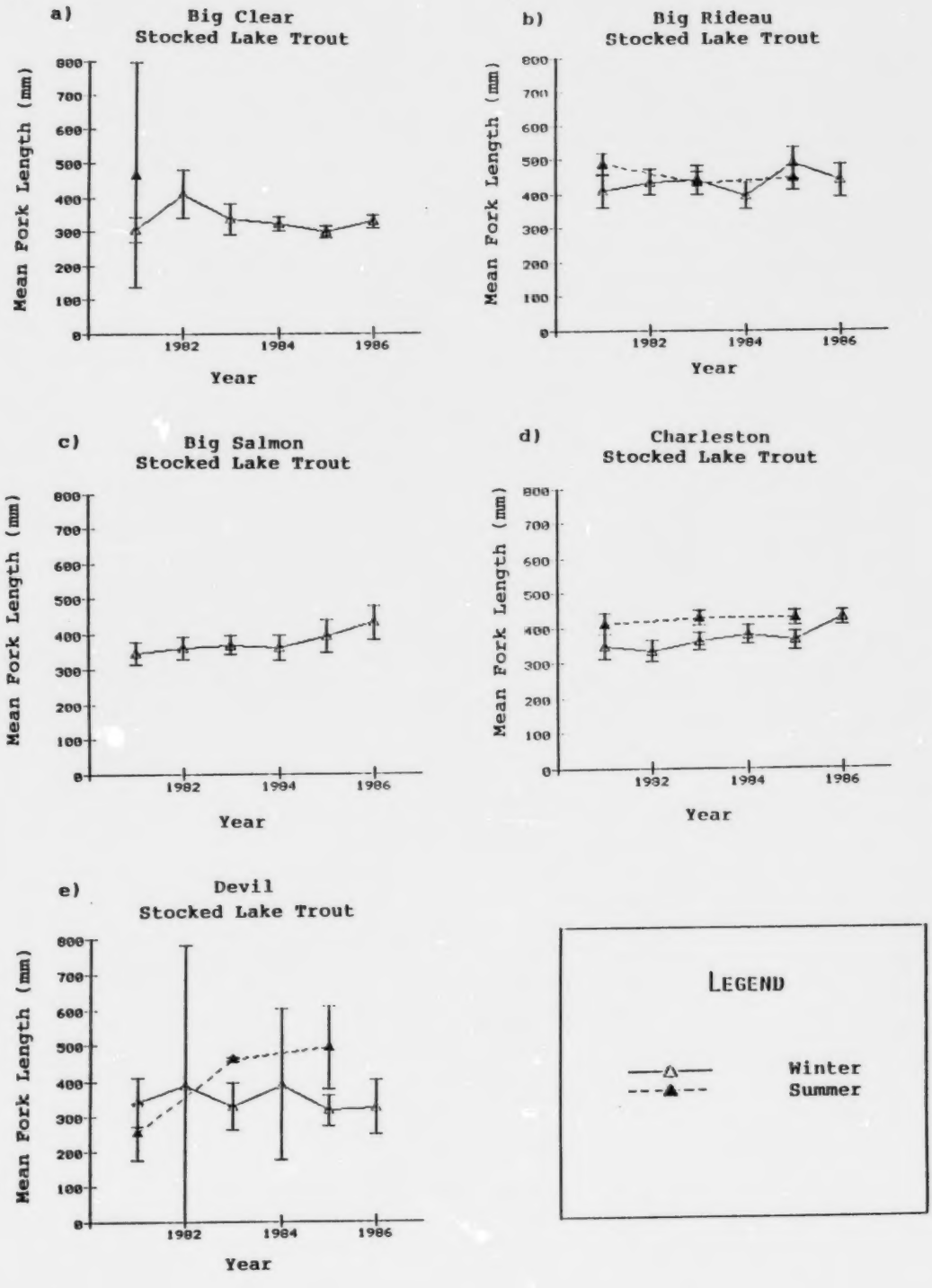

Figure 10a-e. Winter and summer mean fork length (mm) of stocked lake trout in the anglers harvest on five lakes over the study period (1981 to 1986).

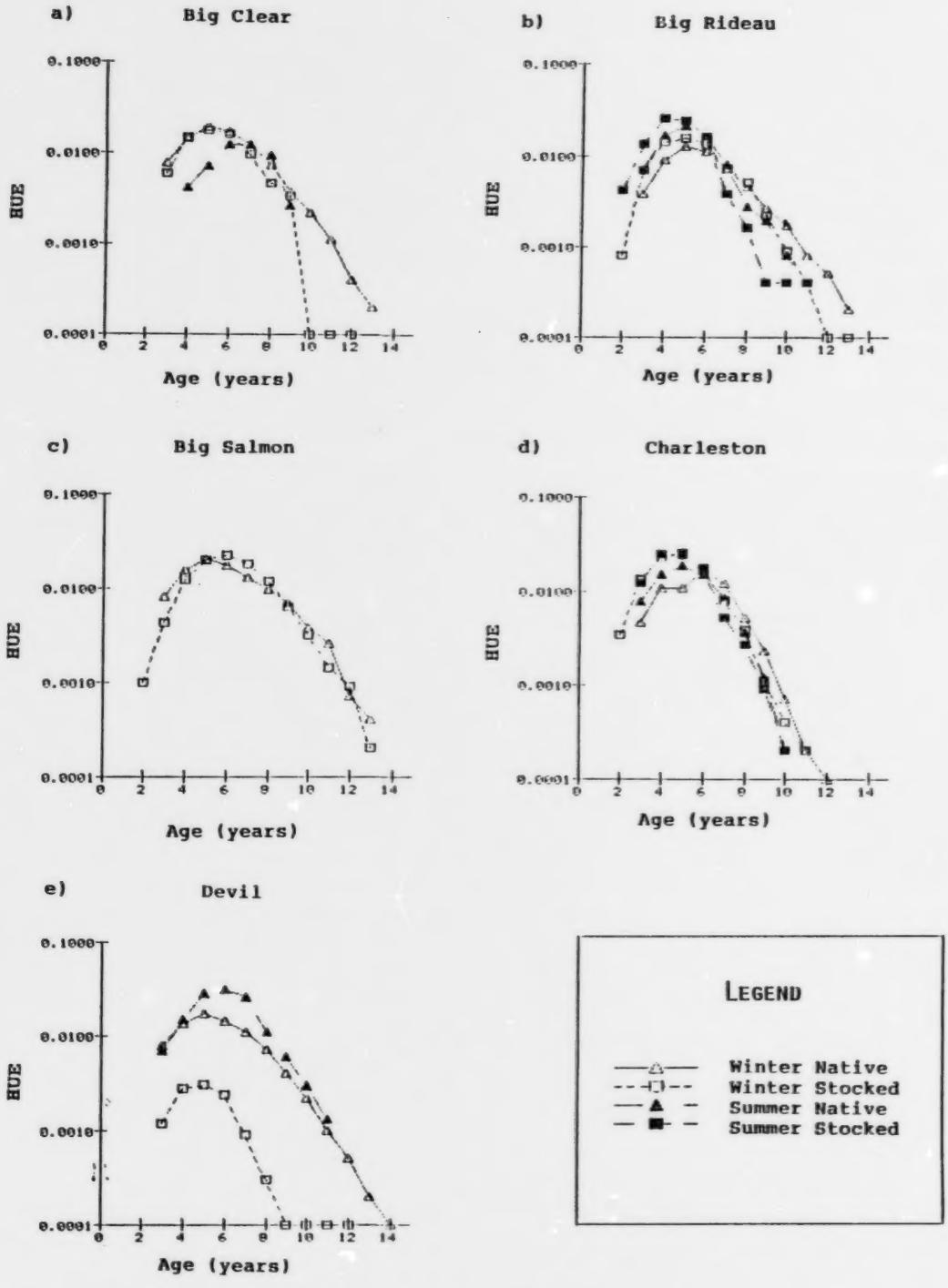

Figure 11a-e. Average annual age specific HUE's (log scale) for **native** and **stocked** lake trout harvested during winter and summer seasons. These 'catch curves' were used to calculate total annual mortality (see text for explanation).

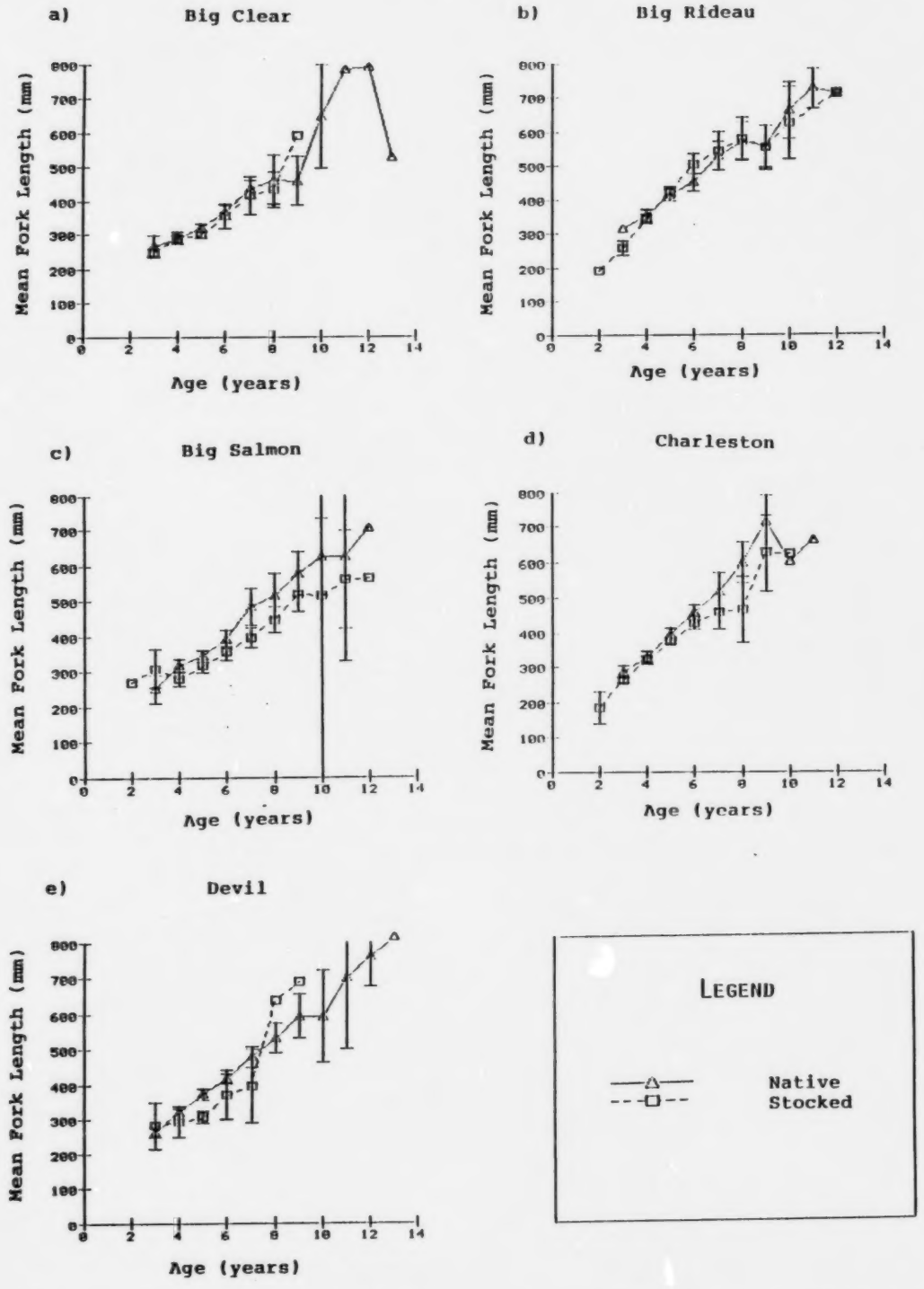

Figure 12a-e. Mean fork length-at-age for **native** and **stocked** lake trout sampled during the six winter creel surveys on five study lakes over the study period (1981 to 1986).

Table 4. Data summary for Big Rideau Lake. Results are based on data collected from six winter and three summer creel surveys. See text for explanation of calculations.

		Effort (angler hours/ha)	Yield kg/ha	RORY	Abundance CUE (C.V.)	HUE (C.V.)	Mean Fork Length (mm)	Total Annual Mortality (Ages VI to IX)	Mean Growth Index for Ages VI and VII
Winter									
	Native	-	.22	.22	-	.053 (.47)	464	.38	-
	Stocked	-	.21	-	-	.063 (.24)	435	.44	-
	Total	3.0 (1.3*)	.43	-	.155 (.20)	.116	449	-	-
Summer									
	Native	-	.77	.76	-	.076 (.11)	468	.53	-
	Stocked	-	.75	-	-	.089 (.19)	456	.70	-
	Total	7.1	1.52	-	.207 (.20)	.165	463	-	-
Annual									
	Native	-	.99	.98	-	-	-	-	115%
	Stocked	-	.96	-	-	-	-	-	123%
	Total	10.1	1.95	-	-	-	-	-	-

(* = # rods/angler; blank = not applicable)

4.2.2. Yield

Yields of native and stocked lake trout during the winter season were consistently low (Fig. 3b and 4b), corresponding to low angling effort at this time (6-year means of 0.22 and 0.21 kg/ha/yr respectively) (Table 4). Summer lake trout yields, like effort, were three to four times those of winter (3-year summer means=0.77 and 0.75 kg/ha/yr for native and stocked fish respectively).

The mean annual native lake trout yield (0.99 kg/ha/yr) was very close to the recommended annual lake trout yield of 1.01 kg/ha/yr (RORY=0.98). The mean annual yield of stocked lake trout was similar (0.96 kg/ha/yr). Thus, the mean annual yield of all trout was 1.95 kg/ha/yr (Fig. 5b).

4.2.3. Relative Abundance

No obvious year-to-year trends in lake trout angler CUE were apparent (Fig. 6b). Catches per unit effort were generally less in winter (6-year mean=0.155) than summer (3-year mean=0.207). (NOTE: Summer CUE's for lake trout anglers on Big Rideau Lake were consistently greater than those on other lakes in the data set.)

Harvest per unit effort for winter angled native lake trout increased from a low of 0.034 in 1983 to 0.101 in 1986 (6-year mean=0.053, C.V.=0.47). Stocked lake trout HUE decreased during the last three winters of the study period from 0.076 in 1984 to 0.042 in 1986 (6-year mean=0.63, C.V.=0.24) (Figs. 7b and 8b, Table 4).

Summer HUE's remained fairly consistent and somewhat greater than winter values with 3-year means of 0.076 (C.V.=0.11) and 0.089 (C.V.=0.19) for native and stocked lake trout respectively. Thus, stocked lake trout were slightly more abundant in the anglers harvest in both seasons.

4.2.4. Mean Fork Length of the Harvest

The mean fork length of native lake trout harvested during the winter varied slightly over the study period (6-year mean=464 mm) (Table 4) with a peak occurring in 1983 (Fig. 9b). The mean fork lengths of native lake trout harvested during the three summer creel surveys were remarkably consistent from year to year (3-year mean=468 mm), and were not significantly different from winter values ($p>.05$).

The mean fork length of stocked lake trout generally followed the same pattern (Figure 10b), again with no significant differences in mean fork length between winter (6-year mean=435 mm) and summer (3-year mean=456 mm) (Table 4).

There was no significant difference in the mean fork length of native and stocked lake trout in Big Rideau Lake ($p>.05$).

4.2.5. Mortality

Lake trout in Big Rideau were generally recruited to the fishery at age VI except for stocked fish in the summer season

which recruited at age VII. More lake trout in older age classes were harvested during the winter fishery. Few stocked lake trout from older age classes were harvested (Fig. 11b).

Total annual mortality for native lake trout was less for winter data (0.38) than for summer (0.53). Estimates of winter and summer mortality were greater for stocked lake trout but followed the same seasonal pattern as native fish (0.44 and 0.70 for winter and summer respectively) (Table 4).

4.2.6. Growth

In contrast to the other four lake trout lakes, the mean fork length at age VI was greater for stocked lake trout (mean=505 mm, n=25) than native lake trout (mean=450 mm, n=32, $p<.05$) in Big Rideau Lake (Fig. 12b). However, there was no significant difference at age VII (mean=529 mm, n=19 for native and mean=542 mm, n=14 for stocked lake trout, $p>.05$).

Mean fork length-at-age for native and stocked lake trout greatly exceeded the Ontario growth standard with growth indices of 115 and 123% respectively (Table 4).

4.3. BIG SALMON LAKE

As mentioned previously, volunteer creels were conducted during the summer open season on Big Salmon Lake. Angler response during the first two years was good, with a low percentage of defaced or incomplete report cards. However, data from the 1985 census were discarded due to poor angler participation and increasing uncertainty regarding our estimation methods (i.e. as the park was developed for multi-user use, our method of expanding the catch, harvest, and effort data reported by anglers became unreliable). Estimates for 1981 and 1983 are probably quite reliable. The decline in angling effort from 1981 to 1983 reflects a reduction in accessibility to the lake during construction along the only access road during the summer of 1983.

4.3.1. Angling Effort

Mean angler effort during the winter over the 6-year study period was 15.5 hours/ha. Most anglers used two lines (mean number of rods/angler=1.9).

Although there was a sharp reduction in angler effort during the summer of 1983, total angler effort for the 1981 to 1983 period was very high (mean = 14.2 hours/ha) (Fig. 2c, Table 5).

4.3.2. Yield

Yield of native lake trout was very high during both seasons (mean winter and summer yields were 1.48 and 2.25 kg/ha/yr with RORY values of 2.14 and 3.26 respectively) (Table 5) with peak yields occurring in 1981 and 1986 (Fig. 3c). Year-to-year trends in yield did not follow that of angler effort (Fig. 2c) indicating that angler success varied among years (Section 4.3.3).

Table 5. Data summary for Big Salmon Lake. Results are based on data collected from six winter and two summer (summer 1985 volunteer creel data thrown out) creel surveys. See text for explanation of calculations.

		Effort (angler hours/ha)	Yield kg/ha	RORY	Abundance CUE (C.V.)	HUE (C.V.)	Mean Fork Length (mm)	Total Annual Mortality (Ages VI to IX)	Mean Growth Index for Ages VI and VII
Winter	Native	-	1.48	2.14	-	.099 (.50)	417	.27	-
	Stocked	-	.89	-	-	.096 (.35)	376	.41	-
	Total	15.5 (1.9*)	2.37	-	.218 (.42)	.195	395	-	-
Summer	Native	-	2.25	3.26	-	.067 (.24)	**	**	-
	Stocked	-	.56	-	-	.020 (.05)	**	**	-
	Total	14.2	2.81	-	.102 (.26)	.087	**	-	-
Annual	Native	-	3.73	5.40	-	-	-	-	103%
	Stocked	-	1.45	-	-	-	-	-	88%
	Total	29.7	5.18	-	-	-	-	-	-

(* = # rods/angler; ** = insufficient data; blank = not applicable)

Yield of stocked lake trout more closely paralleled the annual pattern of angler effort (Fig. 4c). The mean yield of stocked lake trout during the winter was 0.89 kg/ha/yr compared with 0.56 kg/ha/yr in summer. Yield of all lake trout combined was 2.81 kg/ha/yr in summer and 2.37 kg/ha/yr in winter. Annual yield of stocked lake trout (1.45 kg/ha) was less than half that of native lake trout (3.73 kg/ha) (Fig. 5c, Table 5).

4.3.3. Relative Abundance

Winter angler CUE varied widely over the six years of the study but was quite high overall (mean=0.218, C.V.=0.42) (Fig. 6c). Catches per unit effort during the 1981 and 1983 summer seasons were very low (mean=0.102, C.V.=0.26) (Table 5).

Winter HUE also varied greatly from year-to-year with similar patterns for native and stocked lake trout (Figs. 7c and 8c). Six-year mean HUE's for native and stocked lake trout were 0.099 (C.V.=0.50) and 0.096 (C.V.=0.35) respectively (Table 5).

Mean summer HUE values for 1981 and 1983 were 0.067 (C.V.=0.24) and 0.020 (C.V.=0.05) for native and stocked lake trout respectively.

4.3.4. Mean Fork Length of the Harvest

The mean fork length of winter harvested native lake trout increased in 1985 following a slight decline in 1984 (Fig. 9c). The mean fork length of stocked lake trout increased steadily over the study period from 346 mm in the winter of 1981 to 429 mm in 1986 (Fig. 10c).

The mean fork lengths of native lake trout were greater (6-year mean=417 mm) than those of stocked fish (6-year mean=376 mm) ($p<.05$) (Table 5). No lake trout were sampled during the summer.

4.3.5. Mortality

Catch curves (Fig. 11c) indicate that native lake trout were recruited to the fishery one year earlier (age VI) than stocked lake trout (age VII) during the winter season. Age classes up to age XIII were well represented for both native and stocked fish. Curves were similar after recruitment age, though stocked lake trout declined somewhat more quickly. Total annual mortality estimates were therefore less for native (0.27) than stocked (0.41) lake trout (Table 5).

No age data were available for the summer season.

4.3.6. Growth

Mean fork lengths-at-age for the native lake trout of Big Salmon Lake were similar to the growth standard (growth index=103%); but greater than those of stocked lake trout (growth index=88%) at ages VI (native: mean=393 mm, n=24; stocked: mean=356 mm, n=27) and VII (native: mean=484 mm, n=15; stocked: mean=395 mm, n=31) ($p<.05$) (Fig. 12c, Table 5).

4.4. CHARLESTON LAKE

4.4.1. Angling Effort

Angling effort was consistent from year-to-year (Fig. 2d) but about three to four times greater in summer (3-year mean=22.5 hours/ha) than winter (6-year mean=6.6 hours/ha) (Table 6). Thus, mean annual effort was very high on Charleston Lake, totaling 29.1 hours/ha.

Lake trout anglers used a mean of 1.3 rods/angler during the winter season.

4.4.2. Yield

Native lake trout yield (Fig. 3d), like effort, was about three to four times greater in summer (3-year mean=2.04 kg/ha/yr), than winter (6-year mean=0.63 kg/ha/yr). Yields of stocked lake trout were slightly lower than native lake trout during both winter (6-year mean=0.46 kg/ha/yr) and summer (3-year mean=1.71 kg/ha/yr) seasons. The annual yield of stocked lake trout appeared to increase over the study period (Table 6, Fig. 4d).

Total annual yield was slightly higher for native than stocked lake trout (2.67 and 2.17 kg/ha respectively) and well in excess of the recommended total annual yield (0.89 kg/ha, RORY=3.00) (Fig. 5d, Table 6).

4.4.3. Relative Abundance

Catch per unit effort during the winter season increased from 0.271 in 1981 to 0.329 in 1983, then decreased to 0.206 by 1986 (6-year mean=0.275, C.V.=0.31) (Fig. 6d, Table 6). Angler CUE was less in the summer season (3-year mean=0.207, C.V.=0.25); but showed the same pattern of an increase followed by a decrease.

The HUE of native lake trout during both summer and winter seasons was consistently less in magnitude and greater in variation than that for stocked lake trout (native HUE: 6-year winter mean=0.071, C.V.=0.31; 3-year summer mean=0.062, C.V.=0.36) (stocked HUE: 6-year winter mean=0.099, C.V.=0.25; 3-year summer mean=0.100, C.V.=0.13) (Table 6).

The HUE for all lake trout was only slightly less in the summer (3-year mean=0.162) than in winter (6-year mean=0.170); reflecting a greater release rate during the winter (compare with CUE values above).

Overall, lake trout abundance as reflected by CUE and HUE values was comparatively high on Charleston Lake (Figs. 6d, 7d, 8d).

4.4.4. Mean Fork Length of the Harvest

The mean fork length of the harvest was very consistent from year-to-year for native and stocked lake trout. However, there was a slight decrease in mean fork length for native lake trout and a slight increase for stocked fish over the study period

Table 6. Data summary for Charleston Lake. Results based on data collected from six winter and three summer creel surveys. See text for explanation of calculations.

		Effort (angler hours/ha)	Yield kg/ha	RORY	Abundance CUE (C.V.)	HUE (C.V.)	Mean Fork Length (mm)	Total Annual Mortality (Ages VI to IX)	Mean Growth Index for Ages VI and VII
Winter									
	Native	-	.63	.71	-	.071 (.31)	444	.57	-
	Stocked	-	.46	-	-	.099 (.25)	368	.60	-
	Total	6.6 (1.3*)	1.09	-	.275 (.31)	.170	401	-	-
Summer									
	Native	-	2.04	2.29	-	.062 (.36)	476	.57	-
	Stocked	-	1.71	-	-	.100 (.13)	420	.61	-
	Total	22.5	3.75	-	.207 (.25)	.162	444	-	-
Annual									
	Native	-	2.67	3.00	-	-	-	-	115%
	Stocked	-	2.17	-	-	-	-	-	104%
	Total	29.1	4.84	-	-	-	-	-	-

(* = 1 rods/angler; blank = not applicable)

during winter creel surveys (Fig. 9d and 10d).

Both native and stocked lake trout were generally of greater mean fork length in the summer harvest (native: 3-year mean=476mm; stocked: 3-year mean=420 mm) than in winter season (native: 6-year mean=444 mm; stocked: 6-year mean=368 mm) ($p<.05$). The smaller size of lake trout captured in winter was reflected in a greater release rate at this time (see Section 4.4.3.). Native lake trout were larger than stocked fish ($p<.05$) (Table 6).

4.4.5. Mortality

Catch curve analysis revealed that native lake trout recruited to the summer fishery earlier (age VI) than to the winter fishery (age VII). Stocked lake trout were fully recruited at age VI in both seasons. Descending limbs of the curves were very similar for native and stocked lake trout in both seasons (Fig. 11d).

Total annual mortality estimates for native lake trout were high at 0.57 in both seasons. Stocked lake trout showed even higher mortalities of 0.60 and 0.61 for winter and summer seasons respectively (Table 6).

4.4.6. Growth

Mean fork length-at-age values for native lake trout were significantly greater than those for stocked fish ($p<.05$) at age VI (mean=458 mm, n=55 for native and mean=426 mm, n=50 for stocked lake trout) but not significantly greater at age VII (mean=520 mm, n=19 for native and mean=459 mm, n=15 for stocked lake trout) (Fig. 12d).

Growth indices for both native and stocked lake trout exceeded the Ontario growth standard (115% and 104%, respectively) (Table 6).

4.5 DEVIL LAKE

4.5.1. Angling Effort

Angler effort was fairly consistent from one year to the next (Fig. 2e). Mean effort for the 15-day winter season (6-year mean=11.6 hours/ha) was almost equal to that for the summer (3-year mean=12.7 hours/ha). Mean mean annual effort was 24.3 hours/ha (Table 7) indicating very heavy fishing pressure. Most anglers used two lines during the winter season (6-year mean=1.9 rods/angler).

4.5.2. Yield

Yield of native lake trout during the winter was fairly consistent from year-to-year on Devil Lake (Fig. 3e). Yield during summer was less consistent but closely paralleled angler effort. Lake trout yield was two to three times greater in summer (3-year mean=2.51 kg/ha/yr) than winter (6-year mean=0.94 kg/ha/yr) (Table 7). Annual yield of native lake trout (3.45 kg/ha)

Table 7. Data summary for Devil Lake. Results are based on data collected from six winter and three summer creel surveys. See text for explanation of calculations.

		Effort (angler hours/ha)	Yield kg/ha	Yield RORY	Abundance CUE (C.V.)	Abundance HUE (C.V.)	Mean Fork Length (mm)	Total Annual Mortality (Ages VI to IX)	Mean Growth Index for Ages VI and VII
Winter									
	Native	-	.94	1.08	-	.080 (.46)	418	.35	-
	Stocked	-	.08	-	-	.012 (.50)	348	.66	-
	Total	11.6 (1.9*)	1.02	-	.119 (.29)	.092	409	-	-
Summer									
	Native	-	2.51	2.89	-	.115 (.25)	489	.52	-
	Stocked	-	.10	-	-	.008 (.38)	403	**	-
	Total	12.7	2.61	-	.161 (.16)	.123	484	-	-
Annual									
	Native	-	3.45	3.97	-	-	-	-	105%
	Stocked	-	.18	-	-	-	-	-	90%
	Total	24.3	3.63	-	-	-	-	-	-

(* = 4 rods/angler; ** = insufficient data; blank = not applicable)

greatly exceeded the recommended yield of 0.87 kg/ha (RORY=3.97) (Table 7).

Stocked lake trout contributed only marginally to the total annual yield of lake trout (Figs. 4e and 5e)) even though Devil Lake is stocked at rates similar to the other lakes (Table 2).

4.5.3. Relative Abundance

Angler CUE during the winter season increased over the study period from a low of 0.092 in 1982 to 0.179 in 1986, but decreased during summer creels from 0.190 in 1981 to 0.139 in 1985 (Fig. 6e). Mean CUE's were less in winter (6-year mean=0.119, C.V.=0.29) than summer (3-year mean=0.161, C.V.=0.16) (Table 7).

Angler HUE's for native lake trout showed the same year-to-year pattern as CUE's but the trends were more dramatic (Fig. 7e). Harvest per unit effort increased steadily from 0.031 in 1981 to 0.137 in 1986. Summer HUE declined over the study period but was, on average, higher (3-year mean=0.115, C.V.=0.25) than the mean winter HUE (6-year mean=0.080, C.V.=0.46) (Table 7). Harvest per unit effort of stocked lake trout was very low and the coefficient of variation was high (6-year winter mean HUE=0.012, C.V.=0.50; 3-year summer mean HUE=0.008, C.V.=0.38). However, HUE of stocked lake trout did increase marginally over the study period (Fig. 8e).

4.5.4. Mean fork length of the harvest

The mean fork length of native lake trout harvested during the winter season initially increased from 1981 to 1982, decreased gradually to 1985, and then increased again slightly in 1986 (Fig. 9e). The 6-year winter mean was 418 mm (Table 7). Summer mean fork lengths were more consistent and generally greater (3-year mean=489 mm) but not significantly greater ($p>.05$). Stocked lake trout were significantly smaller ($p<.05$) than native lake trout (mean fork length=348 mm in winter and 403 mm in summer).

4.5.5. Mortality

Catch curves indicated native lake trout recruited to the winter fishery one year earlier (age VI) than the summer fishery (Fig. 11e). More older fish were caught during the summer and the descending arm of the catch curve was more gentle in slope than for the winter. For stocked lake trout, HUE values were very low and declined rapidly with age.

Winter and summer total annual mortality estimates for native lake trout were 0.35 and 0.52 respectively (Table 7). The mortality estimate for stocked lake trout was very high at 0.66 (winter estimate; insufficient summer data).

4.5.6. Growth

Mean fork lengths-at-age were much greater for native than stocked lake trout in Devil Lake (except for ages VIII and IX which represent only one fish each) (Fig. 12e). Mean fork

length-at-ages VI and VII were 417 mm (n=53) and 478 mm (n=37) respectively for native lake trout and 371 mm (n=8) and 395 mm (n=2) respectively for stocked lake trout.

Fork lengths were slightly greater than the Ontario growth standard for native lake trout (growth index=105%) but less for stocked lake trout (growth index=90%) (Table 7).

5. STATUS OF THE LAKE TROUT FISHERIES

Generally, a high proportion of annual angler effort and lake trout yield occurred in the summer for the large readily accessible lake trout lakes (Big Rideau, Charleston, and Devil Lakes). Conversely, angler effort and yield tended to be greater in winter for the smaller lakes where summer travel and access were more restricted (Big Clear and Big Salmon Lakes) (Table 8). Note however, that the winter season was of very short duration (16 days) while the summer season extended over three months (96 days). Thus, lake trout yield per unit effort (kg/hr) was greater during the summer season for all lakes (Table 8). Though CUE's were higher in winter for Big Clear and Charleston Lakes, the lake trout were of smaller size. By contrast, though there was no significant difference in the size of lake trout harvested between seasons for Big Rideau and Devil Lakes, CUE's were higher in the summer season.

Table 8. Percentage of annual effort and yield and the yield per unit effort (kg/hr) of all lake trout which occurred during winter and summer seasons (1981 to 1986) on the five study lakes.

	% Effort		% Yield		Yield/Effort (kg/hr)	
	Winter	Summer	Winter	Summer	Winter	Summer
Big Clear	90.4	9.6	88.5	11.5	.107	.132
Big Rideau	29.7	70.3	22.1	77.9	.143	.214
Big Salmon	52.2	47.8	45.8	54.2	.153	.198
Charleston	22.7	77.3	22.5	77.5	.165	.167
Devil	47.7	52.3	28.1	71.9	.088	.206

5.1. NATIVE LAKE TROUT POPULATIONS

In the following discussion we assess the level of angler exploitation on the native lake trout populations in the five study lakes. The indices of exploitation are summarized in Table 9 for the native lake trout populations.

5.1.1. Big Clear Lake

Our 6-year study shows that the native lake trout population of Big Clear Lake was overexploited during the winter season with high angler effort and yield. Conversely, summer fishing pressure and yield were light. Angler HUE of native lake trout was highly variable, suggesting a stressed population. However, for summer data, this variation may be partially a reflection of our sampling intensity relative to the low amount of fishing effort (Barnes et al. 1984, Loftus 1984). The mean length of harvested fish appeared to decline over the study period, again indicating overexploitation. The relatively low annual mortality and growth rates indicate that the native lake trout population of Big Clear Lake had not yet responded to the high level of exploitation observed during the 1981 to 1986 study period.

5.1.2. Big Rideau Lake

We consider the estimated annual angling effort over the 6-year study period (10.1 hours/ha) on Big Rideau Lake to represent moderate pressure. However, large areas of Big Rideau Lake do not provide suitable habitat for lake trout. Hence, the fishing pressure on the native lake trout population may in fact be quite high. Annual yield of native lake trout approached the recommended yield. However, angler HUE during winter increased over the study period possibly indicating an increase in recruitment. Summer HUE values were consistently high. Total annual mortality rates appear acceptable and the mean length of harvested lake trout has remained stable. Native lake trout growth rates are among the highest for inland lakes in Ontario reflecting the predominance of alewife in their diet. We suggest that Big Rideau was exploited at a maximal, but acceptable level both during the 6-year study period and in the recent past.

5.1.3. Big Salmon Lake

Lake trout angler effort and yield were very high over the 6-year study period. However, apart from variable winter HUE's, the native lake trout population does not presently show signs of overexploitation. Angler success was high, the mean fork length of the harvest was stable and the annual mortality rate was very

Table 9. Summary table listing the indices of exploitation for the native lake trout populations only in the five study lakes.

Lake	Season	Effort (angler hours/ha)	Yield kg/ha	Yield RORY	Abundance HUE (C.V.)	Mean Fork Length (mm)	Total Annual Mortality (Ages VI to IX)	Mean Growth Index for Ages VI and VII
Big Clear	Winter	17.9	1.24	2.34	.087 (.39)	378	.40	-
	Summer	1.9	.16	.30	.049 (.39)	470	.54	-
	Annual	19.8	1.40	1.64	-	-	-	94%
Big Rideau	Winter	3.0	.22	.22	.053 (.47)	464	.38	-
	Summer	7.1	.77	.76	.076 (.11)	468	.53	-
	Annual	10.1	.99	.98	-	-	-	115%
Big Salmon	Winter	15.5	1.48	2.14	.099 (.50)	417	.27	-
	Summer	14.2	2.25	3.26	.067 (.24)	**	**	-
	Annual	29.7	3.73	5.40	-	-	-	103%
Charleston	Winter	6.5	.63	.71	.071 (.31)	444	.57	-
	Summer	22.5	2.04	2.29	.062 (.36)	476	.57	-
	Annual	29.1	2.67	3.00	-	-	-	115%
Devil	Winter	11.6	.94	1.08	.080 (.46)	418	.35	-
	Summer	12.7	2.51	2.89	.115 (.25)	489	.52	-
	Annual	24.3	3.45	3.97	-	-	-	105%

(** = insufficient data)

low. Growth of native lake trout in Big Salmon Lake is comparable to the 'average' Ontario lake trout population. These results suggest that the native lake trout population of Big Salmon Lake was not overexploited prior to our study period but may have been overexploited during the study period.

5.1.4. Charleston Lake

We consider the native lake trout population of Charleston Lake to have been overexploited during the 6-year study period. Effort, yield, mortality rate, and growth rate were all high. Native lake trout abundance remains quite high as indicated by angler success rate but variation in HUE was also fairly high. The mean fork length of the harvest was stable. We conclude that this lake trout fishery has been overexploited for some time (prior to and during our study period).

5.1.5. Devil Lake

Though angling effort and yield were high over the study period, native lake trout abundance also remained high with an acceptable total annual mortality rate. Angler HUE during the winter season increased dramatically over the course of this study suggesting an increase in recruitment. (An increase in recruitment would cause an inflated mortality estimate (Hoyle and Stewart 1987). Though the mean fork length of the harvest declined over the study period, this may also have resulted from an increase in recruitment of young age classes to the fishery. Nevertheless, native lake trout yield during the summer alone far exceeded recommended levels and should be monitored closely.

5.2. STOCKED LAKE TROUT POPULATIONS

Four of five lakes (Big Clear, Big Rideau, Big Salmon, and Charleston Lake) relied heavily on stocked lake trout, roughly 40 to 60% by number of the total annual lake trout harvest. The contribution of stocked lake trout to the total annual lake trout yield was somewhat less due to the smaller size of stocked fish, ranging from 28 to 50% for the same lakes. By contrast, few stocked fish were angled from Devil Lake (about 10% by number and 5% by weight). Some interesting differences between the population characteristics of native and stocked lake trout emerged from this study.

Angler HUE for stocked fish showed less year-to-year variation (at least in winter creels) in all lakes except Devil. This result may suggest that natural variation in the recruitment of native fish in these four lakes may be greater than variation in stocking rates which are fairly consistent from year to year.

Total annual mortality rates were greater for stocked lake trout than native lake trout in all lakes (Tables 3 to 7). Stocked lake trout grew more slowly than native lake trout in all lakes except Big Rideau. Thus, although stocked lake trout generally recruited to the fisheries at the same age, they were of smaller size. Stocked lake trout disappeared from the fisheries at lower ages than native fish.

Stocked lake trout performed particularly poorly in Devil Lake. Angler HUE for stocked fish was very low and highly variable. Stocked lake trout grew slowly and experienced a high rate of mortality. Assessment of the Devil Lake lake trout spawning population (RLFAU data) indicates that stocked lake trout rarely appear on the spawning shoals and thus probably do not contribute to natural reproduction. In addition, genetic analysis (electrophoretic study conducted in 1987) reveals no introgression between native and stocked lake trout stocks (P. Ihssen pers. comm.). We recommend that the lake trout stocking program be discontinued on Devil Lake.

It is not presently known whether natural or angling mortality (catchability) or both was higher for stocked lake trout compared with the native lake trout of our study lakes. In Charleston Lake, stocked lake trout recruited to the winter fishery one year earlier than native fish even though native lake trout were larger compared with stocked fish of equivalent age. Stewart (1987) found that stocked lake trout recruited to the sports fishery one year earlier than native fish in Dickey Lake. These data suggest a greater catchability for stocked fish. MacLean et al. (1981) found that native lake trout showed higher survival rates than stocked fish in four Ontario Lakes, however, growth rates appeared similar. They suggested that the status of the native lake trout fishery influenced stocked fish survival through predation by large native lake trout on stocked fish (MacLean et al. 1981). Competition (eg. for food and/or spawning sites) between native or previously stocked lake trout (Gunn et al. 1987), and stocked lake trout may also be important.

We suggest that stocked lake trout will perform poorly in lakes with strong native populations. Devil Lake supports this suggestion since it possesses the 'best' (based on combined winter and summer HUE) native lake trout population of our five study lakes and stocked fish suffer high mortality and slow growth rates.

To date our study lakes have received lake trout originating from several Ontario stocks. However, Charleston Lake is scheduled to receive yearling lake trout in the spring of 1989 that were hatched from eggs collected from this lake's native stock. The performance of these fish should be monitored closely. In addition, our observations lend support for experimental management programs using, for example, different strains and initial sizes at stocking. Plosila (1977) found substantial differences in survival between two strains of lake trout stocked into nine lakes in New York State. Gunn et al. (1987) found that survival of stocked lake trout increased with

size at the time of stocking (see also Stewart 1987).

In this study, differences between native and stocked lake trout (i.e. higher yields, faster growth, and possibly lower natural mortality for native lake trout) clearly demonstrate the benefits of managing for native stocks.

6. SUMMARY

1) Creel surveys were conducted annually for the two week winter lake trout season and biennially for the three month summer lake trout seasons on five southeastern Ontario lake trout sport fisheries (1981 to 1986). Estimates of lake trout angler effort, yield, relative abundance, mean length of the harvest, total annual mortality, and growth were determined for native and stocked lake trout.

2) The data served to highlight differences in the characteristics of winter and summer lake trout sport fisheries and in the performances of native and stocked lake trout. These data were useful in evaluating the current level of angler exploitation and the impact of past exploitation on these lake trout populations.

3) Angling effort and lake trout yield during the compressed two week winter season were as great or greater than for the three month summer season on the two small lakes (Big Clear and Big Salmon) where summer travel and access were restricted. On the three large readily accessible lakes, effort and yield during the winter season ranged from about 20 to 50% that of the total annual yield. When lake trout yield was expressed on a per effort basis (kg/ha), it was greater during the summer season for all five lakes.

4) Annual lake trout angling effort was considered high on all lakes ranging from 10.1 angler hours/ha on Big Rideau to 29.7 hours/ha on Big Salmon Lake. Annual yield of native lake trout greatly exceeded recommended yields (by 250 to 550%) in all lakes except Big Rideau where the estimated annual yield was roughly equivalent to the recommended yield.

5) Catch per unit effort (CUE) ranged from 0.119 on Devil Lake to 0.275 on Charleston Lake during the winter season and from 0.102 on Big Salmon Lake to 0.207 on Big Rideau and Charleston Lakes during the summer season. No consistent differences in angler catch rates were observed between winter and summer seasons among lakes.

6) Harvest per unit effort (HUE) data were used to determine the relative abundance and variation in abundance of native and stocked lake trout. Stocked lake trout comprised 46 to 58% of the anglers lake trout harvest during the winter and 23 to 62% in the summer for Big Clear, Big Rideau, Big Salmon, and Charleston

Lakes; but only 13% and 6% for winter and summer respectively in Devil Lake. Variation in abundance was generally greater for native lake trout; again with the exception of Devil Lake where stocked fish performed very poorly.

7) The mean fork length of harvested native lake trout was significantly less during the winter season than in the summer in Big Clear and Charleston Lakes (no summer data for Big Salmon Lake). There was no difference in Big Rideau or Devil Lakes. Too few stocked lake trout were sampled during the summer in Big Clear and Devil Lakes to make comparisons between seasons, however, the mean fork length of stocked lake trout was significantly greater in summer in Charleston Lake. Again there was no difference between seasons in Big Rideau Lake.

Native lake trout were of significantly greater mean fork length than stocked fish in the anglers harvest (at least for the winter season as too few stocked lake trout were sampled during the summer in some lakes).

Mean fork length-at-age data showed that stocked lake trout grew more slowly than native fish in all lakes except Big Rideau. Growth indices indicated that native lake trout grew very quickly (greater rate than the Ontario 'average') in Big Rideau and Charleston Lakes reflecting heavy exploitation rates and the predominance of alewife in their diets. The growth shown by native lake trout in Big Clear, Big Salmon, and Devil Lakes was similar to the Ontario 'average'.

8) Estimates of total annual mortality were calculated based on catch curve analysis separately for lake trout sampled during winter and summer seasons. Mortality estimates based on winter HUE data were lower than summer estimates for Big Clear, Big Rideau, and Devil Lakes. The reason for this was not clear. Winter and summer estimates were identical on Charleston Lake. (Summer data were insufficient to calculate mortality for Big Salmon Lake.) Stocked lake trout suffered higher mortality rates than native fish in all lakes.

7. ACKNOWLEDGEMENTS

Thanks to J. Gunn, P. Hulsman, S. Kerr, and T. Stewart for reviewing earlier drafts of this report. We thank all field crews for data collection and acknowledge Garry Smith for coordinating the field programs. Karen Stinchcombe helped with the figures and typing.

8. REFERENCES

Barnes, L.E., R.R. Claytor, N.G. MacLean. 1984. The sport fisheries of Big Clear, Big Rideau, Big Salmon, Charleston, and Devil Lakes, 1983. Ontario Ministry of Natural Resources, Rideau Lakes Fisheries Assessment Unit. Report No. 8. 124 p.

Claytor, R.R., A. Mathers, and N.G. MacLean. 1985. The winter sport fisheries of Big Clear, Big Rideau, Big Salmon, Charleston, and Devil Lakes. Ontario Ministry of Natural Resources. Rideau Lakes Fisheries Assessment Unit. Report No. 13. 74 p.

Gunn, J.M., M.J. McMurtry, J.N. Bowlby, J.M. Casselman, and V.A. Liimatainen. 1987. Survival and growth of stocked lake trout in relation to body size, stocking season, lake acidity, and biomass of competitors. Transactions of the American Fisheries Society 116:618-627.

Healey, M.C. 1978. The dynamics of exploited lake trout populations and implications for management. Journal of Wildlife Management 42:307-328.

Hoyle, J.A. and N.G. MacLean. 1988. A comparison of scales and fin rays for ageing lake trout in five southeastern Ontario Lakes. Ontario Ministry of Natural Resources. Rideau Lakes Fisheries Assessment Unit. Report No. 11. 15 p.

Hoyle, J.A. and T.J. Stewart. 1987. Lake trout exploitation stress assessment on Drag, Dickey, and Twelve Mile Lakes. Ontario Ministry of Natural Resources. Haliburton-Hastings Fisheries Assessment Unit. 50 p.

Lester, N.P. and E.A. Trippel. 1985. Creesys user manual. Ontario Ministry of Natural Resources. Fisheries Branch, Toronto.

Loftus, D.H. 1984. Sample size and the relative precision of estimates obtained from creel survey data. Ontario Ministry of Natural Resources. Haliburton-Hastings Fisheries Assessment Unit. 29 p.

MacLean, J.A., D.O. Evans, N.V. Martin, R.L. DesJardine. 1981. Survival, growth, spawning distribution, and movements of introduced and native lake trout (Salvelinus namaycush) in two inland Ontario Lakes. Canadian Journal of Fisheries and Aquatic Sciences 38:1685-1700.

MacLean, N.G. and G.W. Hooper. 1981. Background report. Ontario Ministry of Natural Resources. Rideau Lakes Fisheries Assessment Unit. Report No. 1. 111 p.

MacLean, N.G. and D.A. Schlesinger. 1982. The sport fisheries of Big Clear, Big Rideau, Big Salmon, Charleston, and Devil Lakes, 1981. Ontario Ministry of Natural Resources. Rideau Lakes Fisheries Assessment Unit. Report No. 4. 117 p.

MacLean, N.G. and W.G. Smith. 1985a. Winter creel census methods manual - coldwater lakes. Ontario Ministry of Natural Resources. Rideau Lakes Fisheries Assessment Unit. File Report No. 15. 47 p.

MacLean, N.G. and W.G. Smith. 1985b. Summer creel census methods manual - coldwater lakes. Ontario Ministry of Natural Resources. Rideau Lakes Fisheries Assessment Unit. File Report No. 19. 56 p.

Ontario Ministry of Natural Resources. 1978. Designation of assessment units. Report of SPOF Working Group Number 1. 66 p.

Ontario Ministry of Natural Resources. 1982. Partitioning yields estimated from the morphoedaphic index into individual species yields. Report of SPOF Working Group Number 12. 71 p.

Ontario Ministry of Natural Resources. 1983. The identification of overexploitation. Report of SPOF Working Group Number 15. 84 p.

Paleczny, E. 1987. The sport fisheries of Big Clear, Big Rideau, Big Salmon, Charleston, and Devil Lakes, 1985. Ontario Ministry of Natural Resources. Rideau Lakes Fisheries Assessment Unit. Draft Report.

Petzold, M. 1980. APL computer programs for creel surveys. Ontario Ministry of Natural Resources. Lake Erie Fisheries Assessment Unit. Report 1980-4. 52 p.

Plosila, D.S. 1977. Relationship of strain and size at stocking to survival of lake trout in Adirondack lakes. New York Fish and Game Journal 24:1-24.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada. 191:382 p.

Ryder, R.A. 1965. A method of estimating the potential fish production of north-temperate lakes. Transactions of the American Fisheries Society 94:214-218.

Schlesinger, D.A. and N.G. MacLean. 1983. The winter sports fishery of Big Clear, Big Rideau, Big Salmon, Charleston,

and Devil Lakes. Ontario Ministry of Natural Resources. Rideau Lakes Fisheries Assessment Unit. Report No. 6. 70 p.

Stewart, T.J. 1987. Lake Trout stocking assessment, Dickey Lake 1981-85. Ontario Ministry of Natural Resources. Haliburton-Hastings Fisheries Assessment Unit. 20 p.

9. APPENDIX 1

Total numbers of lake trout sampled for biological attributes during creel surveys on the five study lakes. Six winter (1981 to 1986 inclusive) and three summer (1981, 1983, 1985) creel surveys were carried out on each lake. Only one lake trout was sampled during the 1985 summer creel survey on Big Clear Lake* and no lake trout were sampled during any summer creel surveys on Big Salmon Lake**.

		Big Clear	Big Rideau	Big Salmon	Charleston	Devil
Winter						
	Native	183	154	128	152	299
	Stocked	150	164	147	200	43
	Total	333	318	275	352	342
Summer						
	Native	7*	95	**	99	123
	Stocked	4*	75	**	132	8
	Total	11*	170	**	231	131
Total						
	Native	190	249	128	251	422
	Stocked	154	239	147	332	51
	Total	344	488	275	583	473